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THE IMPACT OF CLIMATE CHANGE ON THE LOSS OF CAPACITY OF THE FOUM EL GHERZA DAM

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ABSTRACT

The study of climate impacts takes on an importance in scientific research, particularly on water resources. The present study highlights the situation of the capacity of Foum El Gherza dam in relation to the observed climate changes. Located in an arid zone of south-eastern Algeria, this dam is a typical example of a region fragile to climate variability. The methodology adopted in this work is based on the analysis of the evolution of the climatic parameters (precipitation and evaporation) as well as the hydrological parameters (flow yields, and leaks) in relation to the losses of stored water volume of the studied dam. The monthly values of climatic and hydrological data contain a 60-year time series (1950 to 2010). The results obtained show that the losses in capacity coincide with the negative trend of precipitation. Thus, a significant upward trend in evaporation is responsible for the decline in the volumes of water stored within the dam. The correlation analysis expresses that the losses in capacity of the Foum El Gherza dam have a strong impact with leakage and with liquid inflows.

Keywords: climate change, Foum El Gherza, Algeria, arid zone, precipitation, loss of capacity.

INTRODUCTION

Precipitation and temperatures are essential parameters of climate change. Each of these influences the environment, whether through drought, evaporation, or erosion and siltation.

Mediterranean countries are affected by climate change. The latter results in an increase in aridity which promotes water erosion (Shabban *et al*., 1998). In Tunisia, 45% of the total area is threatened by water erosion (Chevalier, 1995). Morocco, records a decrease in annual rainfall of about 15% during the period 1971-2000 (Benassi, 2001). The Mediterranean region is more affected by global warming, which suggests changes in the hydrological cycle (Colmet-Daage, 2018).

In Algeria, drought and erosion are major problems, during the period (1975 to 1998) this country experienced an intense drought (Demmak *et al*., 2001). At the beginning of the eighties, approximately 120 million tons of sediments torn up annually at the level of the basins of northern Algeria (Demmak, 1982). The arid and semi-arid zones of this country are mainly affected by chronic water stress, floods (NADT, 2015 ; karahacane *et al*., 2020).
Algeria records an annual average rainfall contribution estimated at 100 109 m3, and by the influence of intensive evaporation and infiltration and water leaks and discharge into the sea, surface water represents only 12, 5,109 m3 (NADT, 2015).

This study presents the problem of the impact of climate change on the loss of dam capacity in arid regions, of which the Foum El Gherza dam (Wilaya of Biskra) is presented as an example of a study. This vital dam is intended for irrigation for a lively agricultural activity in the desert where intense evaporation is more important than solid inputs and leaks. These phenomena can lead to a great loss of the precious water resource. Therefore the objective of this study is to analyze the influence of climatic and hydrological parameters on the loss of capacity of this dam followed by a study on the correlation between these parameters. The results sought will be used in order to take the necessary precautions to maintain the operation of this dam longer.

MATERIALS AND METHODS

The study region

This study is focused on the Foum El Gherza dam which is located in the arid zone 18km east of the town of Biskra and about 600km south-east of Algiers. It is intended for the irrigation of the palm trees of Sidi Okba in the south west of Seriana in the North and of Thoudra. The dam construction project was designed in 1946. This infrastructure consists of two parts which are an arch of 126m and an abutment of 60m in length each. Its maximum height reaches 73m and its initial capacity is around 47,106 m3.

The El Abiod wadi watershed is located in the Aurès

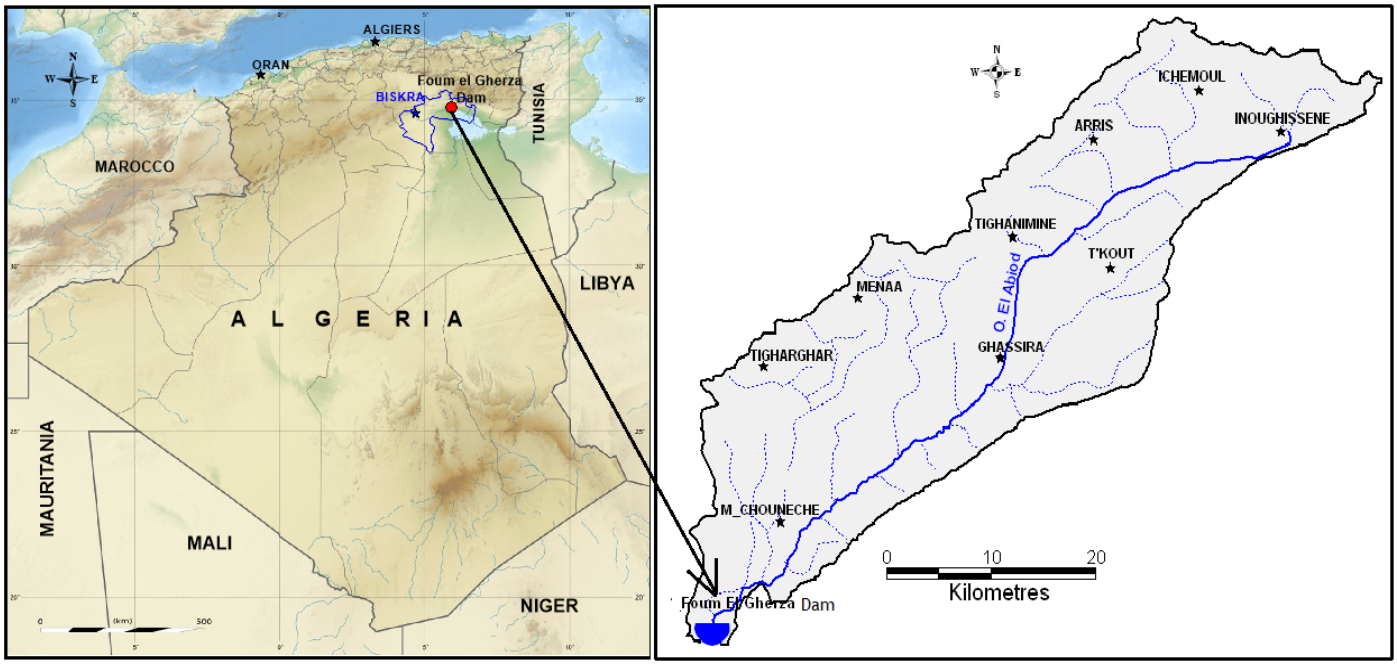


Fig.1. Location of the Foum el Gherza dam, (Benfetta and ouadja, 2017)

massif. It is part of the large basin hydrological of Chott Melhrir which consists of three main wadis: wadi El Abiod; wadi Chenawra and wadi Tkout forming by their confluence wadi Ghassira (Ouadja, 2012).

However, this structure is confronted with three hydraulic problems, intensive evaporation, accelerated siltation of the reservoir and water leaks through the two banks of the reservoir thus threatening the reduction of the useful capacity and even the stability of the reservoir dike.

Data

We have monthly and annual data over a period of 60 years, going from September 1950 to August 2010, including 444 values of evaporation (106 m 3), 444 values of dam water loss (106 m 3) and 444 leakage values (106 m 3), 444 liquid input values (106 m 3), These data are collected from the ANBT service (National Dam and Transfer Agency), and monthly and annual rainfall data in mm (444 values) are collected from the ANHR (National Agency for Hydraulic Resources) services.

Methods

Statistical analysis of long series of precipitation and liquid inputs and evaporations and leaks and loss of dam capacity can identify climatic variations. To facilitate the analysis of the annual variability of the parameters studied, their graphic representation in a box-whisker or box plot is adopted. Box plots represent the parameters studied for each time series at different scales. The analyzed parameters were brought together on the same graph for each scale. And then to justify the influence of these analyzed parameters on the loss of dam capacity, a step of verifying the good correlation between climatic and hydrological parameters is performed by the Pearson correlation matrix.

RESULT AND DISCUSSION

In this section, we make the seasonal and monthly distributions of climatic variables and dam water loss through the box plot.

Figures 02 (a, b), and 03 (a, b), on which were plotted the distributions of precipitation and liquid inputs on a seasonal and monthly scale for a period (1950-2010), show a seasonal variation of these parameters, it appears that on a seasonal scale the regime of precipitation and liquid inputs is very irregular, in which these seasonal factors experience an increase during the wet seasons: autumn, winter and spring, then a decrease during the month. dry: summer.

Regarding the recorded increase in these parameters at the time of autumn, we can explain it by the fact that it is the result of the autumn rains which usually appear in the form of thunderstorms, violent and sudden floods. And for the decrease in liquid intake during winter, this can be explained by the fact that infiltration is very high and that the flow coefficient is lower in winter.

Figures 02 (C), and 03 (C) on which the evaporation distributions on a seasonal and monthly scale have been plotted for a time series (1950-2010), show that the distribution of this parameter is irregular, since '' it experiences an increase beyond the spring, summer and autumn seasons because the summer in the arid zone is characterized by severe low water levels during the months of May, June, July and August, and a decrease at winter time.

Figures 02 (D), and 03 (D), on which the distributions of

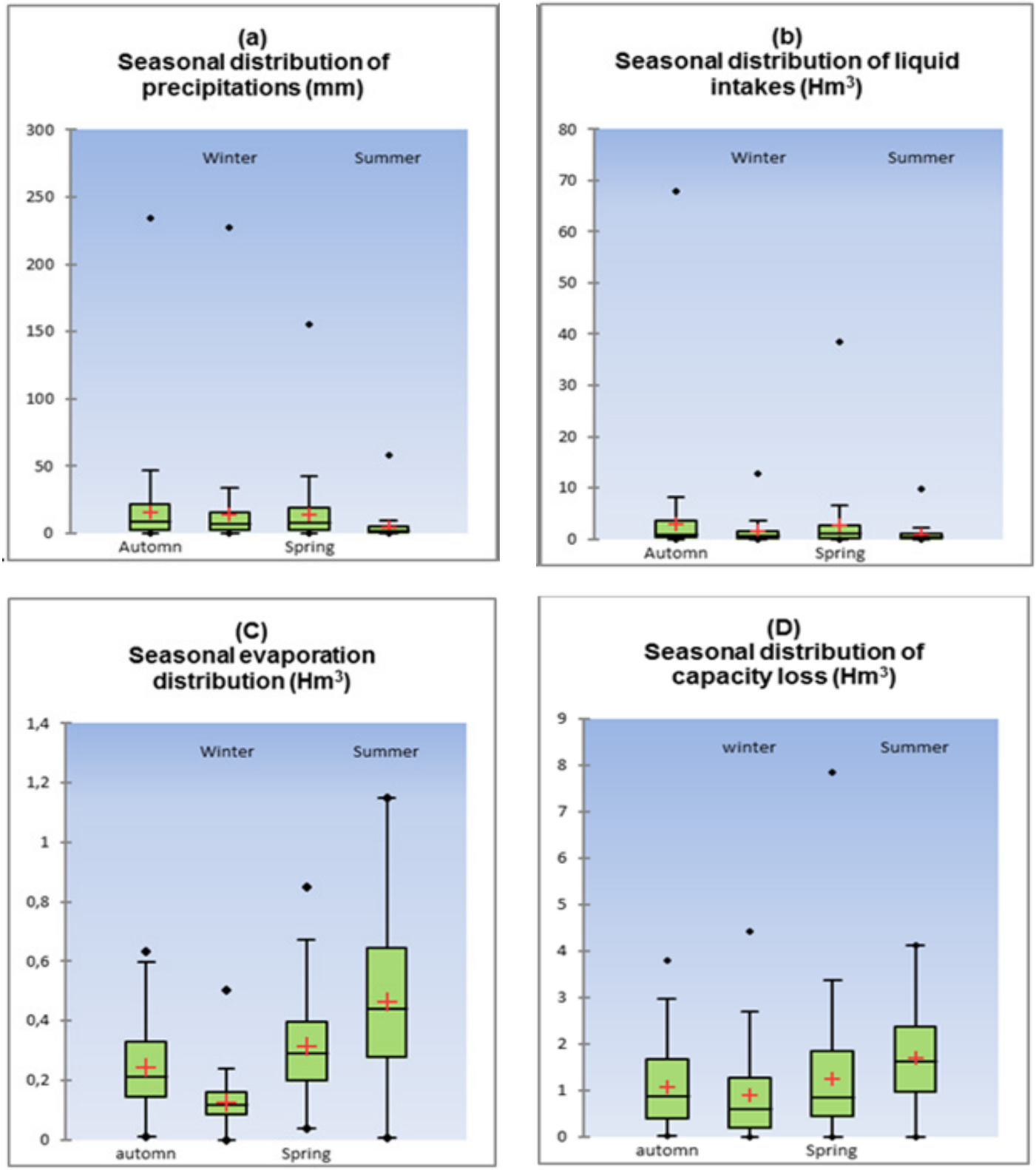


Figure 02: Seasonal distribution of variables (precipitation, liquid inflow, evaporation, leakage) in the Foum El Gherza dam (1950-2010)

water loss on a seasonal and monthly scale were plotted during a period of (1950-2010), show an almost regularity during all the seasons with a small decrease in the summer season. This regularity can be explained by the impact of siltation in the wet season by solid inputs and by strong evaporation in the dry season when the maximum temperature is very high because the dam is installed in an arid zone.

In order to analyze the impact of climate variability on variations in the capacity of the Foum El Gherza dam, two climatic parameters were involved. Indeed, the annual cumulative precipitation (Figure 4-a) and annual evaporation (Figure b-4) are studied with the annual variations in the capacity losses of this dam. These variations are investigated over a period from 1950 to 2010. The losses of capacity coincide with the negative variations in precipitation. This shows that the

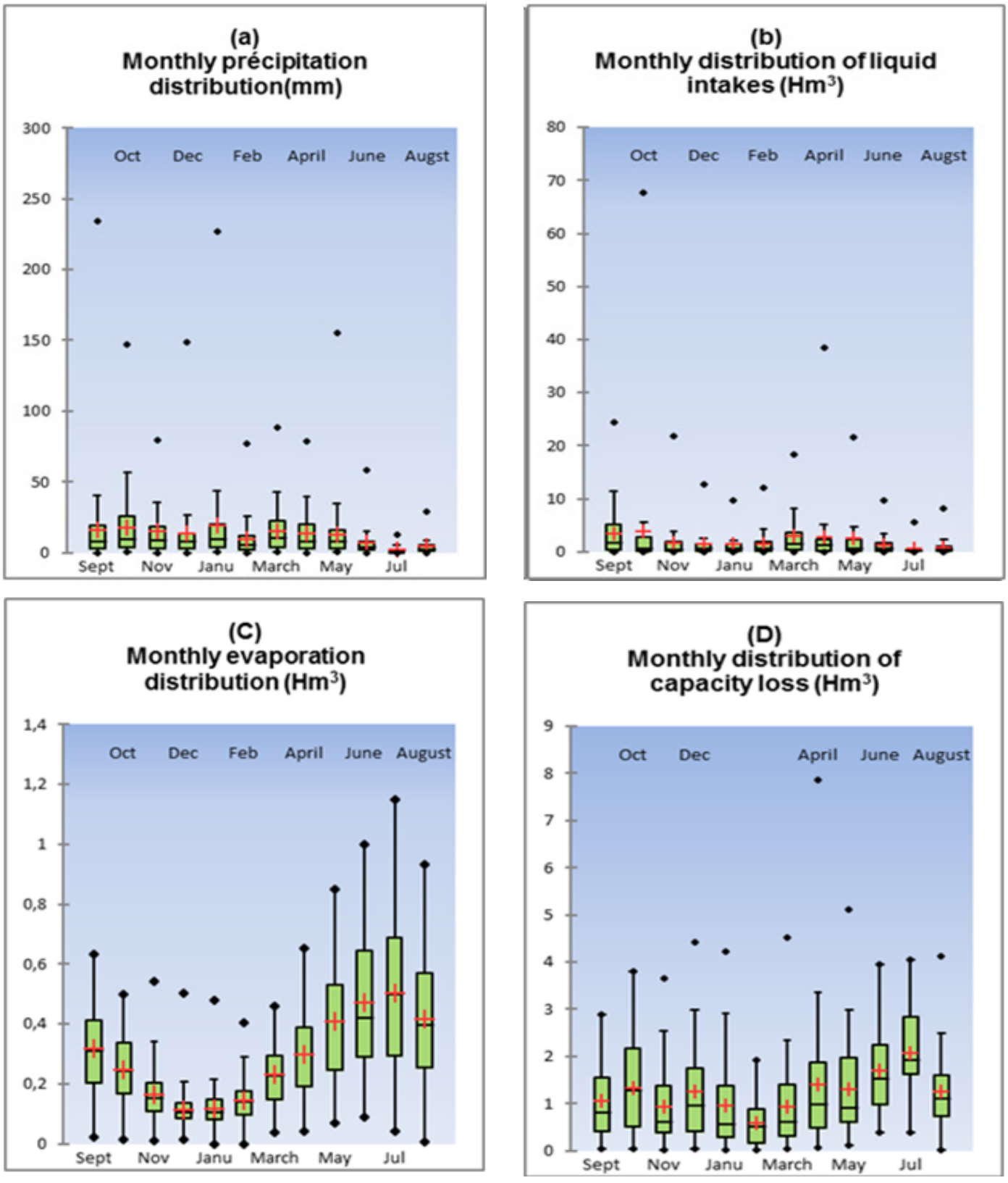
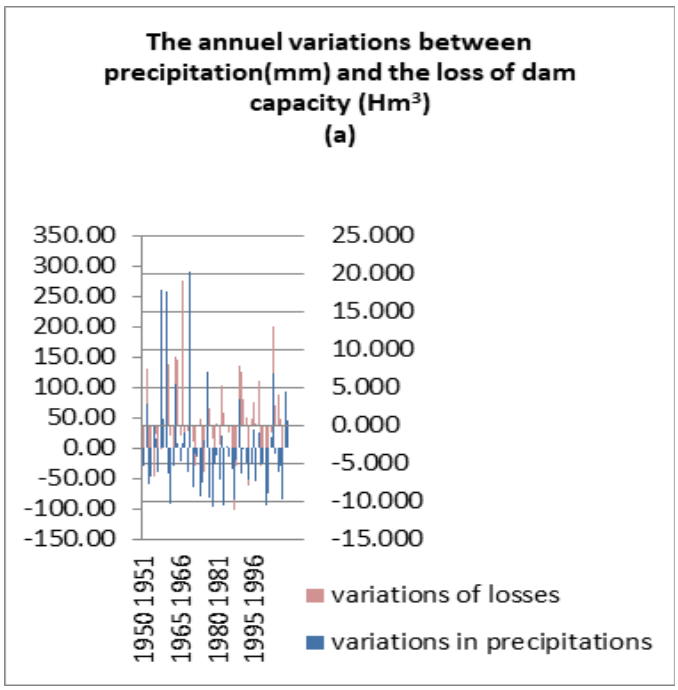


Figure 03: Monthly distribution of variables (precipitation, liquid inflow, evaporation, leakage) in the Foum El Gherza dam

precipitation input mainly influences the increase in the amount of water stored within the dam.

While, the variations in annual evaporation express significant losses in the quantity of water stored during the last decades. This coincides with significant losses (19.06 Hm3 in 1967-1968 and 13.06 Hm3 in 2003-2004) in capacity of the dam. From the graphs presented in Figure 4, it is detected that these two climatic parameters namely: precipitation and evaporation respectively positively and negatively impact the storage capacity of the dam in question. It is imperative to carefully monitor the evolution and variation of these two parameters when managing the water stock in this dam.

On the other hand, the analysis of the variation of liquid



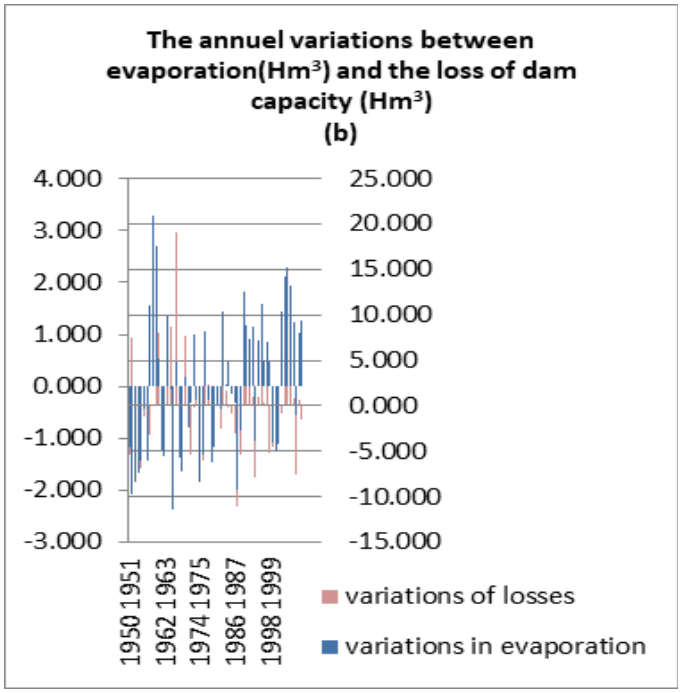
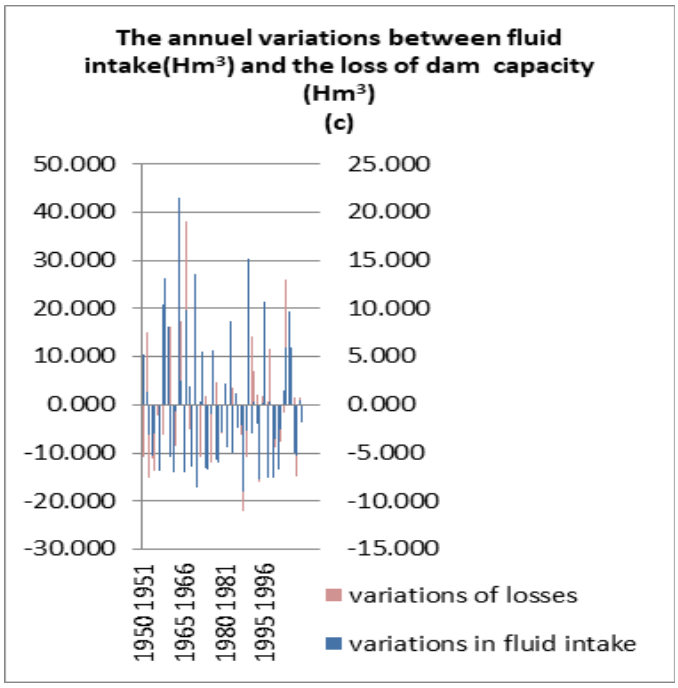


Figure 04: Annual variations between climatic parameters and loss of dam capacity (1950-2010)



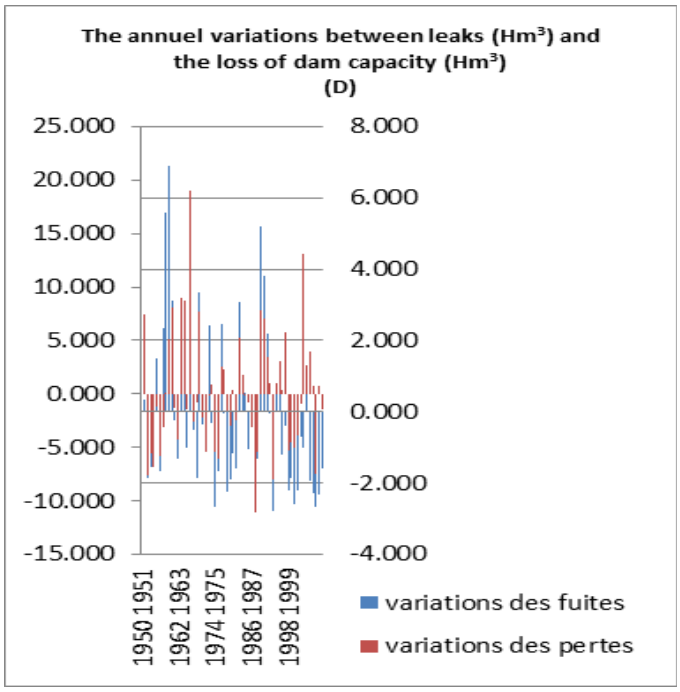


Figure 05: Annual variations between hydrological parameters and loss of dam capacity (1950-2010)

Variable	The evaporation	The precipitation	The fluid intake	The leakage	The losses
The evaporation	1				
The precipitation	0,484	1			
The fluid intake	0,641	0,705	1		
The leakage	0,601	0,557	0 ,685	1	
The losses	0,563	0,406	0,571	0,595	1

inflows with the annual variation of capacity losses are presented in Figure 5-c. It is observed that the greater the amount of liquid intake, the lower the losses. Also, the variations in the quantities of water lost by leaks within the dam (Figure 5-d) show that their evolution follows that of capacity losses. This indicates that the losses in capacity are linked to the leaks present in the dam. From these graphic visualizations, it is noticed that the losses in dam capacity are manifested largely with the leaks than with the liquid inputs. Through this analysis, it is useful to

identify the problem of loss of storage capacity in the dam, around two main causes, namely: evaporation and leaks. Thus, since evaporation is given a climatic parameter, it appropriately expresses the changes that affect climatic conditions within the study region. Since the phenomenon of evaporation is a complex operation where several climatic parameters are involved, namely: temperature, humidity rate, wind speed, etc. So, it is important to study and analyze the evolution and change within each of these parameters in order to better understand the changes that can affect evaporation.

In this part we made the Pearson correlation between these parameters at the annual scale. On the annual scale (Table 1), we noticed that there is a strong annual correlation between climatic parameters and water loss, the correlation coefficient is between 0.571 and 0.406. We also noticed a significant correlation between the leaks and the liquid inputs, the correlation coefficient is equal to 0.685, more that there is a good correlation between the liquid inputs and the precipitation reaches up to 0.705

Discussion

The installation of the Foum El Gherza dam in an arid region was intended for the irrigation of palm trees and which was carried out during the second stage of the history of Algerian hydraulics (1947) and therefore it has a strategic importance and economy in Biskra's life.

Through this study, we have studied the climatic and hydrological parameters which influence the loss of capacity of this studied dam and which shows the successive decrease in the capacity of this dam.

According to the analysis of the seasonal distributions of rainfall and liquid inflows (fig. 2; a), (fig2; b.) And according to the correlation coefficient between these parameters and the loss of capacity (table 1) we concluded that the fall precipitation has a strong influence on the loss of water capacity of the dam located in the arid and semi-arid zone, these results confirm those found by (El Mahi *et al.*, 2012) which indicate that it there is a strong impact of flood events on the seasonal distribution of suspended matter flows. In addition to the seasonality, it is noted that the lithology and the vegetation cover as well as the density currents have an important influence on the amount of rain and the liquid contributions received in the dam because the absence of vegetation cover and the steep slopes favor the flow in the watershed and therefore the acceleration of the siltation of the dam. These remarks are indicated by several authors (NADT, 2015).

The study of the impact of climate change on water resources carried out by the National Water Resources Agency (ANRH, 2009) revealed a persistent drought since the mid-1970s. The results presented (table 1) confirm that there is a highly significant correlation between capacity loss and evaporation. This means that the loss of capacity of the dam was greatly affected by evaporation during summer (figure 2; C) Because summer is generally characterized by severe low water during the beginning of May, June, July, August where the temperature is at its maximum. This result has been demonstrated by several authors (Benfetta *et al*., 2016; - saggai *et al.,* 2016). In order to solve these problems, solutions are possible such as the technique called `` mono-molecular film '', this solution is based on the preservation of water bodies, and increase its stocks by reducing evaporation (Saggai *et al.,* 2016) which concluded that the technique of using molecular films is a very effective means of reducing losses by evaporation.

According to the correlation analysis carried out during the study period 1950-2010, shows that in addition to the effect of siltation and evaporation on the loss of capacity of the studied dam, there is the factor of leak where the correlation between the loss of barrier capacity and the leaks is very significant, this correlation is equal to 0.595 (table 01), and we have also noticed that there is a good correlation between the liquid inputs and the leaks, this correlation is reached up to 0.685 (Table 01.). this can be explained by the fact that the Foum El Gherza dam is built on a massif formed by rigid and cracked Maastrichtian karstic limestone rocks and because of the rapid and light floods, the water flows cause a rapid rise in the level of the lake . So to reduce infiltration into the rock, the only solution is to create a waterproofing veil (Benfetta and Ouadja 2017).

CONCLUSION

Being fundamentally linked to the water regime of the regions of the country, the dams appear to be sensitive to changes in the various components of the hydrological cycle, while it becomes relevant to question how the availability of water in the dams will be influenced. .
The Foum El Gherza dam was subjected to a significant loss of capacity of approximately 27, 21 Hm^3 The aim of this article was therefore to characterize this problem of growing importance.

An analysis of the evolution of climatic and hydrological parameters at the level of the study area was evaluated through precipitation and temperatures and liquid inputs over an observation period of 1950-2010.

Significant variability in the distribution of these parameters was found across the hydro-climatic regime from month to month and season to season.

The search for a relationship between the change in the time series of these parameters and the loss of storage capacity of the Foum El Gherza dam was carried out by the Pearson correlation test. However, it was concluded that the capacity losses coincide with the negative evolution

of precipitation. Also, the significant upward trend in evaporation is also responsible for the decline in the volumes of water stored within the dam, which expresses a significant loss in capacity of this structure considered important for the agricultural sector in this region.

On the other hand, the analysis of the correlation between the storage capacity of the dam and the variation in liquid inflows and losses by leaks respectively showed that the losses in capacity of the dam are strongly manifested with the leaks than with the inflows liquids. Through this analysis, it was found that losses in storage capacity in the dam are mainly caused by evaporation and leaks.

Following the analysis of the issue posed by climate change on the availability of water in this region, it is possible to draw several relevant conclusions.

First, it is essential not to underestimate the impacts that climate change can cause on water resources. It is therefore extremely important to take seriously the threat that currently weighs on water resources.

Secondly, it was possible to observe that the extent of the changes in the hydrological regime that will occur over the next decades is still unknown and a source of many uncertainties, which makes the choice of appropriate adaptation measures complex and delays their application. . It would therefore be relevant to carry out certain studies in order to deepen our knowledge of the impacts of climate change and thus better guide the implementation of the necessary adaptation measures.

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