African Journal of Advanced Pure and Applied Sciences (AJAPAS)

Online ISSN: 2957-644X

Volume 2, Issue 2, April-June 2023, Page No: 160-165

Website: *https://aaasjournals.com/index.php/ajapas/index*

Analysis of the Hydrological Functioning of the Oued Reghaya Watershed in the Context of Climate Change (Tensift, Morocco)

Choukri Bahija[1*], Benchattou Abdelmoumen[1], Ourabit Souad[1], El Ghachi Mohamed[2]

[1] Department of Geography, Laboratory of landscape dynamics-Risks and Heritage, Sultan Moulay Slimane University, B. 524, Beni Mellal, Morocco

[2] Professor of Higher Education, Laboratory of landscape dynamics-Risks and Heritage, Sultan Moulay Slimane University, Beni Mellal, Morocco

Corresponding author: choukribahijastu@gmail.com

Received: March 20, 2023	Accepted: April 28, 2023	Published: May 06, 2023

Abstract:

From global to local, climate change has become a political, social, and major problem for the 21st century [1]. Through several studies of future climate projections, Morocco has been exposed to a series of dry periods, making it vulnerable to climate change [2]. The Reghaya sub-basin is located in the High Atlas of Marrakech; it covers an area of 306 km2 and is considered one of the most important sub-basins of the Oued Tensift. Although the watershed is receiving rainfall and snowfall at high altitudes, the study basin is experiencing very frequent hydrological disturbances. In this sense, we have chosen to study the flows recorded by the Tahanaout hydrometric station, located downstream of the watershed, to extract the hydrological cycles (low and high water) using the determination of the monthly flow coefficient. The hydrometric study of the Oued Reghaya watershed, shows that the flows recorded by the station of Tahanaout have a significant temporal variation. Generally, low water periods are marked in the summer and autumn months, whereas high water periods are marked in the winter and spring months. This work shows that the hydrological regime of the Oued Reghaya watershed is rainy, which makes it vulnerable to events.

Keywords: Flows, Hydrological regime, hydrometric station, Monthly coefficient of flow, Low, Oued Reghaya.

Cite this article as: C. Bahija, B. Abdelmoumen, O. Souad, E. Mohamed, "Analysis of the Hydrological Functioning of the Oued Reghaya Watershed in the Context of Climate Change (Tensift, Morocco)," *African Journal of Advanced Pure and Applied Sciences (AJAPAS)*, vol. 2, no. 2, pp. 160–165, April-June 2023.

Publisher's Note: African Academy of Advanced Studies – AAAS stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

I. Introduction

The Oued Tensift watershed is located in the center of the High Atlas of Morocco and is considered a water tower [3]. Although these mountainous areas receive precipitation throughout the year, this precipitation is irregular and heterogeneous between upstream and downstream. On the one hand, the Oued Reghaya watershed represents a significant portion of water resources and is one of the most active sub-basins of the Oued Tensift [4], and on the other hand, evaporative demand is very high [5]. As a result, surface waters are increasingly overexploited due to socio-economic development and the effects of climate change. These conditions negatively affect water resources in our study area. Regarding the hydrological regime study, we used the hydrometric data available and communicated by the Tensift Water Basin Agency (ABHT) in order to understand the hydrological functioning of the Oued and analyze the occurrences to determine the return periods of the minimum values.

II. Material and methods

1. Study area

With an area of 306 km^2, the Reghaya sub-watershed is located in the High Atlas of Marrakech and is considered one of the most important sub-basins of the Oued Tensift. It is located about forty kilometers south of Marrakech, in the Toubkal massif, between latitudes 30°10" and 30°20", longitudes 7°40" and 8°W. It includes much of North Africa's highest peaks, especially the highest of them, Jabal Toubkal (4165 m).

Its main outlet is located a few kilometers south of the city of Tahanaout on Oued Reghaya, resulting from the conflict of two wadis, Assif Imnene and Assif N'Ait Mizaine. Its administrative boundaries are as follows:

- To the north by the plain of Haouz.
- South by the basin of Assif Tifnout (Haut Souss)
- East by the Ourika basin.
- West by the N'fis basin.

The low-permeable formations (metamorphic and eruptive rocks) occupy 60% of the surface of the sub-basin, and concerning the vegetation cover, it is very sparse on the slopes, with areas of irrigated crops located near the talwegs and slopes being stronger in the upstream part. The average precipitation at the Tahanaout outlet station (1064 m above sea level) is 356 mm/year, with the average flow at the same station being about 1.57 m3/s [4] **(Hajhouji, 2018).**

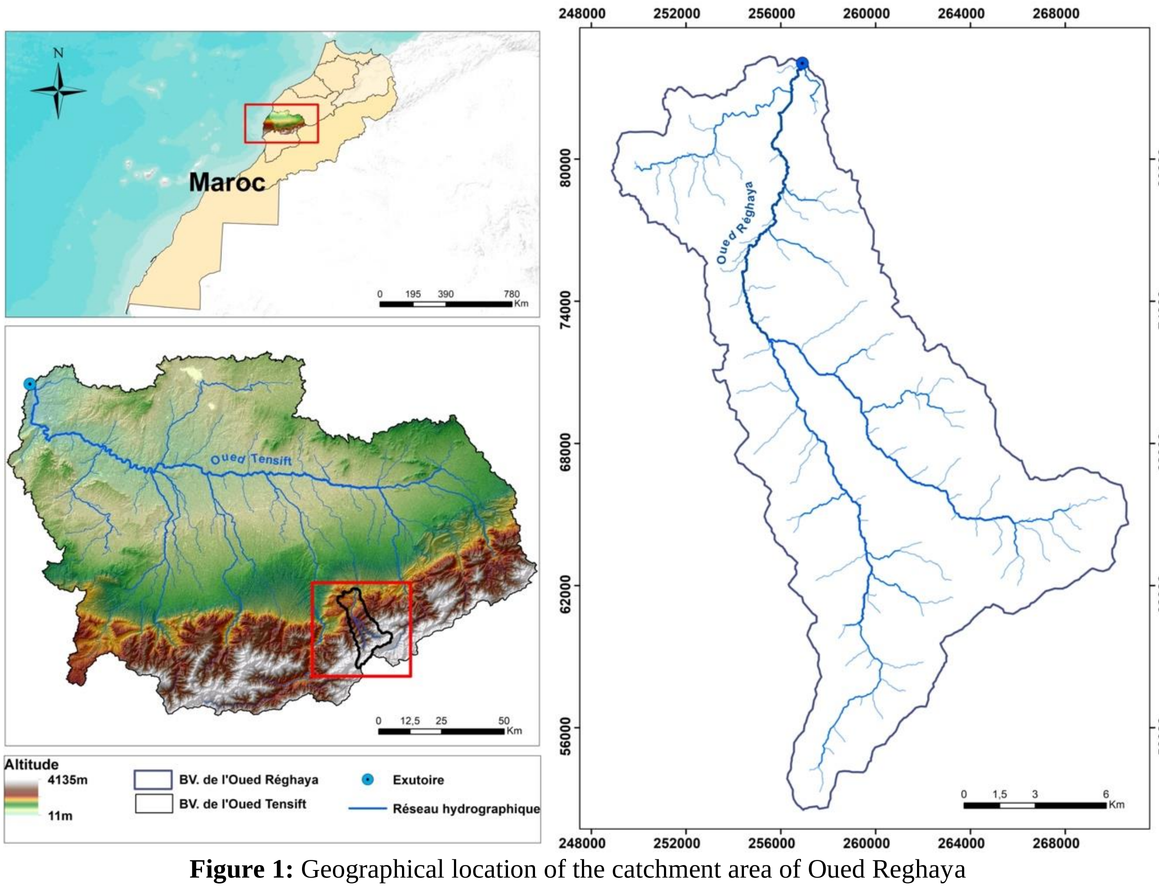

Figure 1: Geographical location of the catchment area of Oued Reghaya

2. Data Sources

In this work, we have used the data provided by the Tensift Water Basin Agency (ABHT) to better achieve the objective of our work. For this purpose, the annual and monthly flow data of a 55-year chronicle (1969–2018) were processed at the Tahanaout station, located downstream of Oued Reghaya, since the choice of this station is based on several criteria, among them:

• This station has the longest data set,

• Its geographical position in relation to the catchment area studied,
• This station has good data quality with a lack of gaps,

Table 1: The characteristics of the measuring station

Station	Stream	In-service date	Data used	Basin area (Km2)	Altitude at outlet (m)	X	Y
Tahanaout	Réghaya	1962	Q (m3/s)	306	1050	255900	80400

3. Interpolation methods

The methodology adopted in this study allows us to understand the hydrological functioning of the Oued Reghaya sub-watershed through the application of the statistical method to time-series hydrometric data. This method usually involves the implementation of statistical tests of homogeneity and reliability for the time series between 1969 and 2018. We proceeded as follows:

- Statistical analysis of annual and monthly recorded flows to extract hydrological cycles.

- Frequency analysis of flows to study past events and define probabilities of future occurrence.
- Calculation of annual flow return periods to characterize natural hazards.
- Extraction of the monthly flow coefficient to understand the hydrological functioning of the Oued.

III. Results and discussion

1. Analysis of annual average flows

1.1. The variation in annual average flows

To define the linear link between the consecutive values of the series, we used the autocorrelation module. It was conducted with the Anderson test [6]. The main objective is to extract a set of information that can tell us about hydrological extremes, as an example of the lows in the study area. Inter-annual variability in flows in the study area is demonstrated from representative data from the Oued Reghaya watershed downstream station.

From the analysis of Figure 2, we can say that the driest years were 1975, 2000, and 2001, where the flow rate was less than 0.50 m3/s, knowing that the interannual module is 1.57 m3/s. In other words, the average annual flows between 1997 and 2008 (for twelve consecutive years) were lower than the interannual module. Annual flows are below average over the watershed of Oued Reghaya.

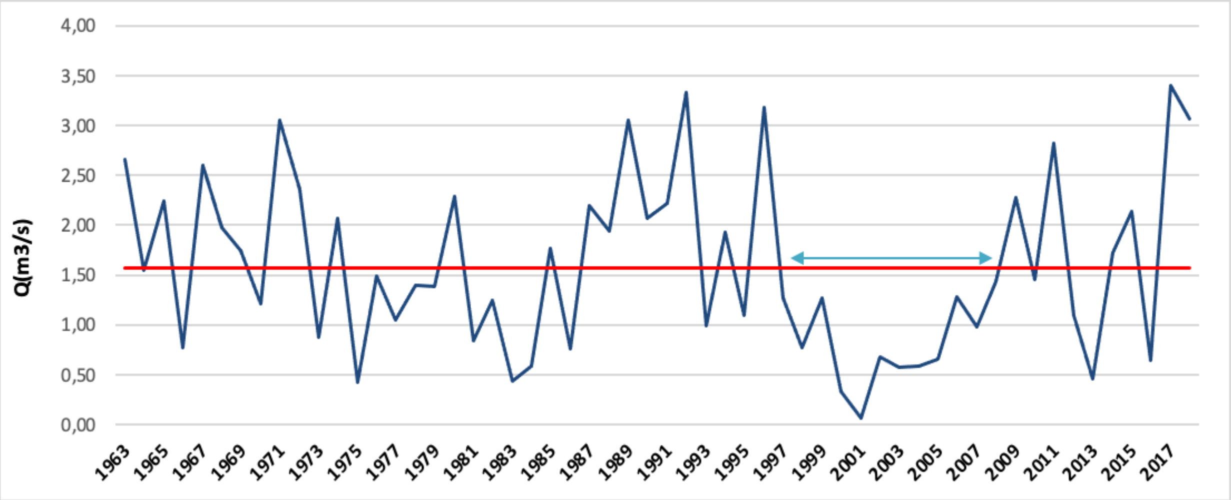

Figure 2: Evolution of the annual flow of the Oued Reghaya, station of Tahanaout (1963–2018)

1.1. Frequency analysis of annual average flows

The assessment of data quality is important for a frequency analysis to have Wilcoxon homogeneity [7]. Knowing that, this method allows us to analyze the occurrence of extreme events with probabilistic significance for future events [8]. In general, the frequency study begins by arranging the flow values in ascending order, giving each variable its rank in the series. Then, we calculate the experimental frequency of the variables using the following formula:

F = (r- 0.3) / (N+ 0.4)
r: the rank of each value
N: sample size

There are several laws to adjust the flow rate, including Gumbel, Gumbel root, Frechet Normale, Racine Normale, Ln Normale, and Weibull [9]. We adjusted the data from the Tahanaout hydrometric station on all the above laws and found that the Gumbel law is the most suitable.

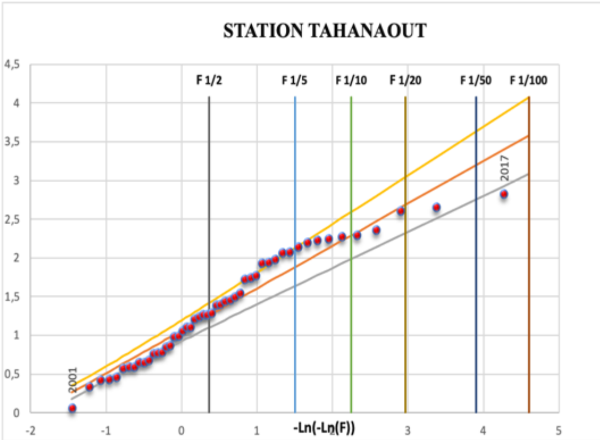

Figure 3: Adjustment of annual average flows, Gumbel laws

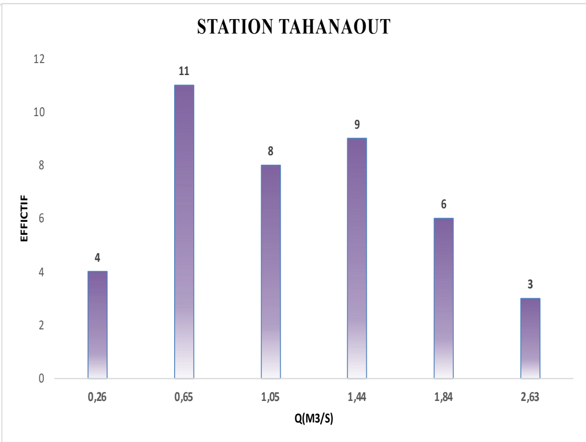

Figure 4: Histogram of the return period of the annual flows

The analysis of Figure 3 shows a good distribution of the points around the right, including the extreme years: the year 2001, which is located at the left end of the histogram, is characterized by very low hydrometric values, in contrast to 2017, which is located in the right part of the histogram with very high flow values throughout the chronicle.

The observation that can be drawn from the histogram and according to Gumbel's law is that the flow rate of 0.65 m3/s is repeated 11 times; it is a low flow, but it is the value responsible for the maximum frequent flow during this chronic.

Table 2 shows the return periods of the minimum annual flow values at the Tahanaout station, the results obtained show that the lowest annual flow is 0.01 m3/s corresponds to a frequency of 1/50, it is repeated once during this chronicle, then, we find the value 0.02 m3/s which corresponds to a frequency of 1/20.

Table 2: Return periods of annual minimum flows according to Gumbel law

Frequency	**1/2**	**1/5**	**1/10**	**1/20**	**1/50**
Return time	2 years	5 years	10 years	20 years	50 years
Tahanaout Station	0,10	0,07	0,05	0,02	0,01

2. Analysis of monthly average flows

2.1. The variation in monthly average flows

The main objective of this module is to give an idea of the distribution of monthly flows in the Oued Reghaya watershed. According to Figure 5, the flows during the period 1963–2018 gradually increase as early as February, when the rivers collect the important precipitation and generate an increase in the flow that continues to reach its maximum in May (spring). The flow then begins to decrease until September, then shows a slight increase in November.

The months of August and September are characterized by very low flows (0.50 m3/s and 0.63 m3/s), while the peak flow is recorded in May (spring), a flow resulting from the combination of rain and snowmelt. Indeed, the seasonal distribution of inputs indicates that the Oued Reghaya watershed has a rainfall regime with a hydrological peak in the spring. In general, low flow rates are reached from July to September (ABHT, 2016).

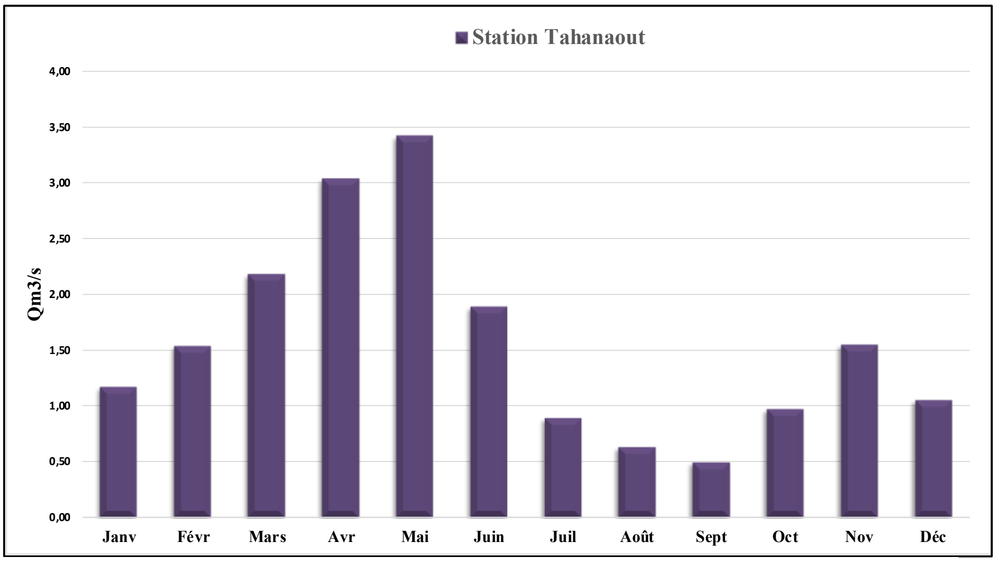

Figure 4: Average monthly flows of the Oued Reghaya, Tahanaout station (1963-2018)

2.2. The monthly coefficient of flow (MCF)

The monthly flow coefficient allows us to compare the monthly inputs of stream regimes and their variation from month to month. Generally, the monthly coefficients of flows below the unit correspond to the months of low water, and the monthly coefficients of flows above the unit represent the months of high water.

$$MCF = \frac{average\ monthly\ flow}{interannual\ module}$$

Figure 6 shows two periods:

- The period of high water is characterized by the months that have recorded an above-average flow; it is hard all the winter season and a part of the spring; this is due to the rainfall inputs, the feeding by the sources, and the melting of the snow.
- The low-water period is characterized by months of below-average flow, which is due to a lack of rainfall inputs in addition to evaporation. We note that the hydrological regime of the Oued Reghaya is influenced by a period of high water and a period of low water, and this in relation to the climatic inputs.

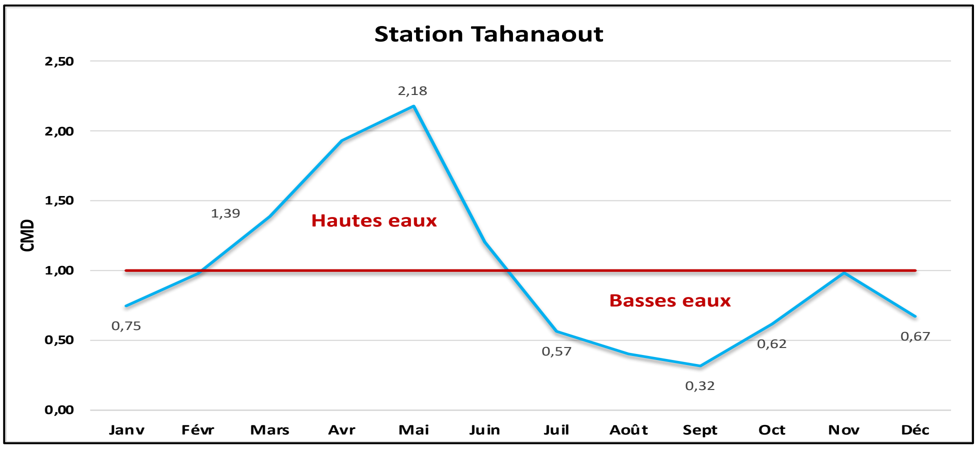

Figure 5: the monthly flow coefficient of the Oued Reghaya, Tahanaout Station

IV. Conclusion

Our work has been carried out to help him with statistical analyses of the hydrological module series. The results indicate that the amount of water discharged annually in the Oued Reghaya is low, more than the socio-economic development, agriculture, and tourism increase the demand for water. The study of the annual variation of flows shows that the driest years during the given chronicle are 1975, 2000, and 2001, where the interannual module is 1.57 m3/s. On a monthly basis, the months of August and September are characterized by low flows (0.63 m3/s and 0.50 m3/s, respectively). The hydrological regime of the Oued Reghaya is marked by a period of high water beginning in February and a period of low water beginning in July.

References

[1] Giddens, A. (2009). Politics of climate change. Polity.

[2] Hulme, M., Mitchell, J., Ingram, W., Lowe, J., Johns, T., New, M., & Viner, D. (1999). Climate change scenarios for global impacts studies. Global Environmental Change, 9, S3-S19.

[3] Boudhar, A., Duchemin, B., Hanich, L., Chaponnière, A., Maisongrande, P., Boulet, G., ... & Chehbouni, G. (2007). Analyse de la dynamique des surfaces enneigées du Haut Atlas marocain à partir des données SPOT-VEGETATION. Science et changements planétaires/Sécheresse, 18(4), 278-288.

[4] Hajhouji, Y. (2018). Modélisation hydrologique du bassin versant de l'oued Rheraya et sa contribution à la recharge de la nappe du Haouz (bassin du Tensift, Maroc) (Doctoral dissertation, Université Paul Sabatier-Toulouse III).

[5] Er-Raki S., Chehbouni A., Khabba S., Simonneaux V., Jarlan L., Ouldbba A., Rodriguez J.C., Allen R. (2010). Assessment 1 of reference evapotranspiration methods in semi-arid regions: Can weather forecast data be used as alternate of ground meteorological parameters? Journal of Arid Environments, 74: 1587-1596.

[6] Salas, J. D., & Yevjevich, V. M. (1972). Stochastic structure of water use time series (Doctoral dissertation, Colorado State University. Libraries).

[7] Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Series in Psychology, McGraw-Hill, New York. xvii + 312 pp.

[8] Meylan, P., Favre, A. C., & Musy, A. (2008). Hydrologie fréquentielle: une science prédictive. PPUR presses polytechniques.

[9] El Ghachi, M. (2007). La Seille: un système fluvial anthropisé (Lorraine, France) (Doctoral dissertation, Metz, université de loraine).