International Journal of Latest Research in Humanities and Social Science (IJLRHSS)
Volume 06 - Issue 04, 2023
www.ijlrhss.com || PP. 591-600

Low-flow: Hydrological definition, statistical identification and regulatory thresholds for precise management and rationalization of water resources

Chakir Mohamed[1], Ghadbane Omar[1], El Ghachi Mohamed[1]
[1]*Dynamics of Landscapes, Risks and Heritage Laboratory,*
Faculty of Letters and Human Sciences, Sultan Moulay Slimane University,
Beni Mellal, Morocco

Abstract: Due to the climate changes that the world is experiencing today, water is considered one of the major challenges in the coming years. Among the risks associated with the severity of climate change are the scarcity and depletion of water resources and the high demand for water. Increasing water use and direct pressure on water sources, both surface and groundwater, will inevitably lead to worsening hydrological droughts. In this respect, the study of low-flow levels has become one of the most important scientific concerns attracting the attention of researchers and policy makers.

At the hydrological level, low-flow is a natural hydrological event that leads to a deficiency of water resources; thus, it was necessary to highlight this recurrent situation, in order to control and propose the thresholds and to determine the mechanisms of its functioning. In this article, we have tried to present a set of hydrological and statistical definitions for the main researchers in this field, with the aim of proposing a complete and precise definition of low-flow level and distinguishing it from other hydrological events. We have considered the difficulty in determining the low-flow due to the absence of precise regulations. These hydrological events are characterised by a particularity according to the climatic, natural and human properties of each basin. Thus, their study is based on the objectives to be achieved, in order to rationally manage periods of water scarcity, in particular in semi-arid areas which experience a great fragility of water resources.

Keywords: Water resources, Low-flow, hydrological definition - statistical definition, determination - management - Morocco.

1. Introduction

Water resource management is one of the major challenges of the 21st century. Indeed, it is affected by many phenomena, both natural and human. Low-flow is one of the hydrological events that concern many countries, because of its impact on economic and environmental life. Some authors say that low-flow is a seasonal event whose severity varies from one river to another (Smakhtin, 2001). This event is manifested by a decrease in the flow of the river, or its drying up at certain periods, due to the rainfall deficit. As a result, the pressure on water resources becomes more severe due to climate change, demographic, and technological development. The demand for water is constantly increasing, which leads to an increase in the water deficit. Thus, studying and determining the low-flow thresholds remains a key issue, which must be linked to the various water uses for better management of the water resource (prediction and predetermination) and a better understanding of the processes affecting this hydrological event and its evolution. Given the difficulties linked to the definition of low- flow, we seek, through this article, to distinguish it from certain hydrological events that may be confused with it. Thus, in a first step, we will rely on the critical and comparative methodological approaches, as levels that interact with each other to achieve a complete and precise definition of the low-flow, as well as on the descriptive approach, which allows the possibility of observing, analysing, and interpreting the data and statistical methods adopted to determine this hydrological event.

2. Water resources and theproblem of low-flow levels:

Given Morocco's situation in the arid and semi-arid context, it has been considered among the North African countries affected by climatic drought. It is characterised by moderate rainfall and high inter-annual variability, and this is clearly reflected in the available water resources. The High Atlas range is located in the heart of Morocco, both from a hydrological and hydrographical point of view it has been considered a water tower of the country, but it presents a great fragility and vulnerability to climatic variability and to anthropic pressure on water resources. The demand for water increases considerably, especially for agriculture, during the dry periods of the year. This increase in demand coincides with periods of the year when the flow is at its lowest, particularly during low-flow levels.

If low-flow is a natural event, which occurs frequently during the year, the impact of human activities and climate change can exacerbate this usual hydrological situation and jeopardise the natural balance, through the quantitative and qualitative impact on water resources. For example, low-flow levels during high flow periods can give it the character of a phenomenon, which occurs at non-habitual times of the year. Given the strong pressure exerted on water resources by continuous demand on the one hand, and high pollution on the other, a good knowledge of the characteristics of low-flow and the determination of its levels must be highlighted, based on scientific indicators and thresholds. This can offer stakeholders and users a distinct vision in the thoughtful and rational management of water scarcity. While water resources are considered a determining factor in sustainable development and in improving the quality of life.

3. Hydrological definition of low-flow:

While floods occur at specific times and can be easily distinguished, low-flow is a more complex event in terms of origin and continuity over time, which makes it difficult to identify and limit.

3.1 General definition of low-flow:

Definitions of low-flow are sometimes imprecise, whether in hydrological dictionaries or in the hydrological literature in general. According to the International Glossary of Hydrology (1992), low-flow corresponds to "the lowest level reached by a river or lake", and in another definition, "the lowest level reached by the tide" in the maritime context, and therefore both definitions did not include the concept of time for low-flow. As for the French Dictionary of Surface Hydrology (Roche, 1986), it gave another definition, taking into consideration the temporal notion: "the lowest annual level reached by a watercourse at a given point" which indicates that it has nothing to do with drought. In this context, the definition of the Geographical Dictionary (George et al. 2000) remains the most interesting, since it defines the scarcity of flow as "a period during which flows are very low and not very variable because they come only from groundwater that is in the process of being depleted or dried up". Dacharry (1996) added in the French dictionary of hydrology that the processes of low-flow generation and drying up are very specific, and that drying up is, in fact, a main process during low-flow periods. Thus, this natural event has a seasonal characteristic, and is subject to temporal and spatial variability, generally resulting from the lack or absence of precipitation, which leads to a decrease in the flow of rivers.

3.2 Distinction between low-flow and lowwater:

Some authors stress the need to distinguish between low-flow and low water. Frecaut (1967), for example, also stresses the difference between these two terms, pointing out that "low-flow or pronounced lean is doubly different from ordinary and annual low water" and Rochefort (1969) indicates that low-flow represents "a more considerable drop in level than that which characterises average low water". While Dacharry (1996) defines low-flow flow as "the exceptionally low-flow of a river, which should not be confused with seasonal low water, even if it is an exacerbation of it", this definition referred to the need to distinguish between low-flow flow and the notion of low water, which is considered an ordinary event in the water cycle, and is defined by the flow below the interannual modulus or the annual average flow (Smakhtin, 2001).

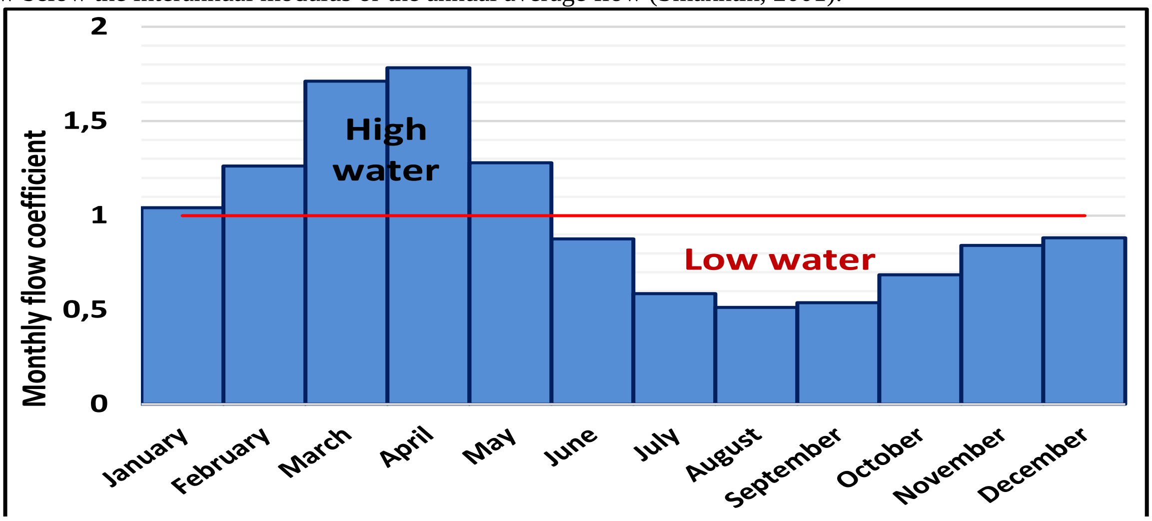

Figure 1: Hydrological regime of the Tassaout watershed at the Tamsemat station (1978-2016)

Thus, the period of low water never represents low-flow, but it often appears during it, and in this case we speak of a low-flow event. However, it can sometimes appear during periods of high water due to climatic conditions or in certain cases of severe hydrological drought, and in this case, we offer the character of a low-flow event (El Ghachi, 2007).

3.3 Distinction between low-flow and hydrological drought:

It is important to distinguish between low-flow and drought, as the terms are often confused. In addition, there is a lack of uniformity in terminology. Drought is a very broad concept that affects many disciplines. There is no universally accepted definition of drought. Thus, it depends on the perspective of the affected field. The International Glossary of Hydrology (1992) proposed a definition of drought as "prolonged absence or marked deficit of precipitation". It also defines hydrological drought as "an abnormally dry period, sufficiently prolonged to cause water scarcity characterised by a significant lowering of river flows, lake levels and/or groundwater tables to below normal values and/or abnormal drying of the soil". So, drought must have a specific temporal character and geographical extent (Tallaksen et al, 2004), and therefore its severity varies according to the magnitude of the deficit, its duration, and its geographical extent.

Low-flows are seasonal events and are part of the hydrological regime of rivers. In the context of drought analysis, the determination of when flow is at or below predetermined deficit thresholds is a key issue. Accepting the definition of low-flow as a period when flow is at or below the assumed threshold (Yevjevich, 1967), it is necessary to distinguish between periods of low-flow (the magnitude of the deficit and the duration) and the possibility of acute hydrological drought, by developing indicators to determine flow thresholds and by separating low-flow into independent events. Thus, drought may include periods of low-flow, but low-flow is not necessarily a drought (Smakhtin, 2001). This hydrological situation is at the origin of a set of processes, which will generate impacts on the natural environment and on human activities.

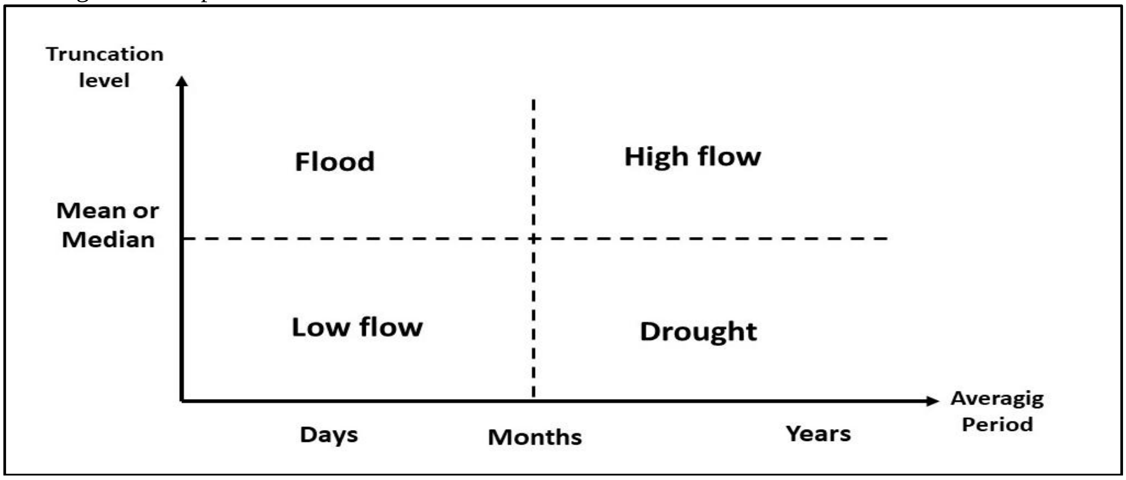

Figure 2: Classification of hydrological events (DRACUP et *al*, 1980).

In this context, it is necessary to follow the threshold selection criterion to distinguish between hydrological drought and low-flow periods. The classification proposed by (Dracup et al, 1980) gives an approximate separation between low-flow and drought by combining the idea of the threshold and the annual average, obtaining four classes of hydrological events.

Thus, the threshold can be chosen in several ways, and the choice depends on the water deficit and the projected objectives. Therefore, the specific thresholds are related to the climatic conditions, the availability of data, as well as the hydrological regime of the catchment. Figure (2) shows the classification of hydrological events according to (Dracup et al, 1980).

Therefore, thanks to the analysis of the definitions in the bibliography, a definition of low-flow can be formulated as follows: "**an ordinary (natural) hydrological event, different from hydrological droughts, which can occur annually, low-flow represents the lowest flow rate reached during low water periods, it becomes a phenomenon when it occurs during high flow periods, these flows come from the emptying of the groundwater, and the drying up represents the process explaining the genesis of the low-flow**". We can emphasise that low-flow is linked to the hydrological regime of the river, and we can also mention anthropogenic low-flow, which is linked to human intervention (dams, withdrawals, etc.).

4. Statistical definition of low-flow:

It is difficult to determine the low-flow because it is not subject to established rules, which reflects the character that these events can have from one year to another. Therefore, low-flow from a statistical point of view can be determined through daily flow, monthly flow, or from moving averages calculated over several days, it is also possible to determine it from flow thresholds, by calculating the volume of the deficit. There is thus a wide variety of methods for characterising low-flow. The term "low-flow indicator" is used mainly to define the values obtained from any low-flow measurement. But the main difficulty lies in the choice of the variable which will allow to characterize this event as well as possible.

4.1 Flow duration curve as low-flow characterisation tools:

The Flow Duration Curve (FDC) is one of the most informative methods of displaying the full range of flows. The method of constructing the CF curve is based on collecting time series values of flows in descending order, assigning flow values to class intervals, and counting the number of occurrences (time steps) in each class interval. The FDC is a structural representation of the hydrological system, reflecting the probability that the flow equals or exceeds a certain threshold, this probability is also called the frequency of exceedance (Lang, 2007). A ranked flow curve is commonly generated logarithmically by calculating a set of percentages of the total number of time steps in the record (Hydrological Practice Guide, 1994).

These curves are sometimes based on weekly or monthly flows to simplify the calculation, however, these curves are less interesting than daily flow curves. They can also be generated for each year of measurement (Gailliez, 2013). The curve is obtained over the whole period of the statistical series studied by calculating the flow of the annual curves for each frequency.

Although the researchers recommend adopting the global method in the calculation of exceedance frequencies. The curve of classified flows is often defined by a certain specific quantity called "Characteristic Flow" (Lang, 2007):

- Characteristic Low-flow (or CLF), which corresponds to the flow equalled or exceeded 355 days per year;
- **Characteristic flows of 11, 9 and 6 months duration**: CF11, CF9 and CF6, flows exceeded respectively 335, 274 and 182 days per year. These characteristic flows can also be expressed as a percentage since they are close to the values exceeded 90, 75 and 50% of the year;
- **Absolute low-flow (or absolute minimum),** which does not necessarily pass through the curve of classified flows but is based in the same way on all the available average daily flows because it represents the lowest known flow of a river.

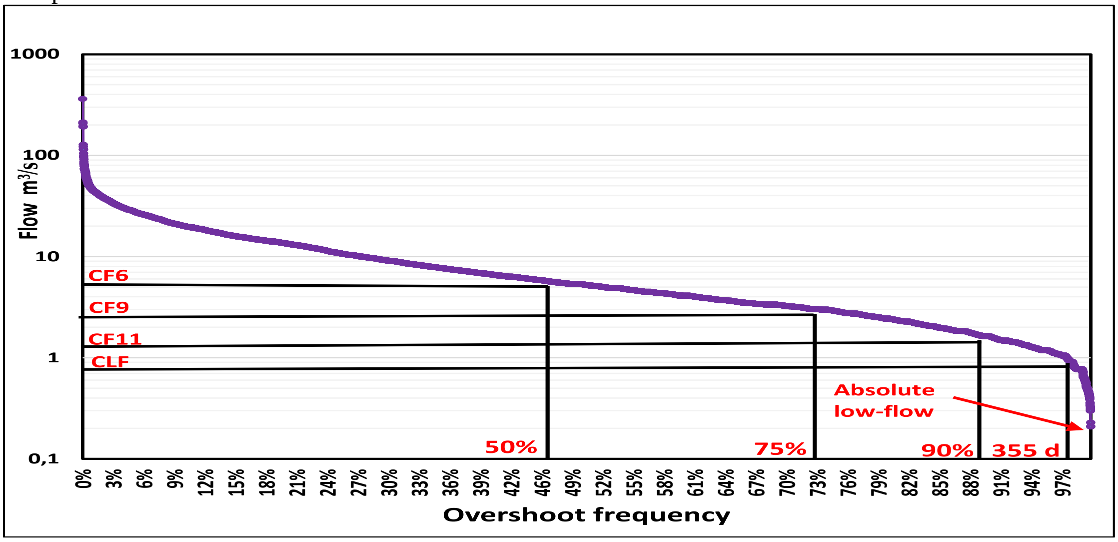

Figure 3: Flow duration curve and associated characteristic flows - Tassaout watershed at Tamsemat station (1978-2016)

These characteristic flows make it possible to approach low-flows in a simple way, without detailed statistical treatment, and to represent the most demanding flow. Many authors have relied on the quantities resulting from the curve of classified flows corresponding to frequencies of exceedance, which concerned a statistical study of the volume and duration of deficit. Whatever the approach chosen, the characteristic of the representation in the curve of classified flows resides, mainly, in its combinatorial aspect, which makes it possible to visualise quickly and globally the principal characteristics of a watercourse (variability of flows, average flows, volume and frequency of low-flow flows...). It is therefore widely used as a water resource management tool. It is also an appropriate indicator to clarify the effect of spatial variations in lithology, topography, climate, and hydrological response of basins (Sauquet et al, 2011).

4.1 Characterization of low-flows on an annual scale:

Many authors tend to conduct a low-flow analysis based on variables extracted from a fixed temporal criterion (extraction of one value per year), knowing that these values do not all represent extreme hydrological cases, especially in the case of very wet years. It is also possible to determine the annual low-flow level according to different time scales in general:

- **The QMNA:**

It corresponds to the minimum annual mean monthly flow and is widely used and applied in the analysis and characterisation of low-flow flows in French-speaking countries (Catalonia, 2006; Lang, 2007; Lang, 2011; Gailliez, 2013; Garcia, 2016). The QMNA is calculated according to different return times (2 years, 5 years, etc.). The 1/5 frequency QMNA is the reference low-flow for the application of the water policy prescribed by the Water Act of 3 January 1992, to calculate the discharge capacity and the quantity of water withdrawals. It is a statistical flow that provides information on the severity of low-flow levels. This flow was chosen for convenience, as it is an easy value to extract from hydrological directories. This is in addition to the computer development that has contributed to the storage of a large, computerised database, and it has therefore become easy to extract other values and variables. But the QMNA remains less representative of the flow event because it is subject to a precise temporal calendar, and because the flow can be observed during an overlapping period between two months. This leads to an overestimation of the flow via the QMNA. On the other hand, studies have shown that it is better to use a shorter time step to give an accurate description of the low-flow, in order to limit the effect of precipitation (Lang. 2007).

- **The VCNd:**

The VCNd are values extracted annually according to a fixed duration of d days. Moving averages calculated from the average daily flows over d consecutive days lead to the calculation of the VCNd, minimum average flow over d days. The period d, often varies between 1, 7, 10 or 30 days. Sometimes longer periods can be used to determine long-term low water periods from flow d = 90 up to d = 284 days. The most appropriate period for the calculation of VCNd is linked to the definition attributed to low-flow, but also to the character of the anthropogenic impact on the watercourse (Lang, 2007).

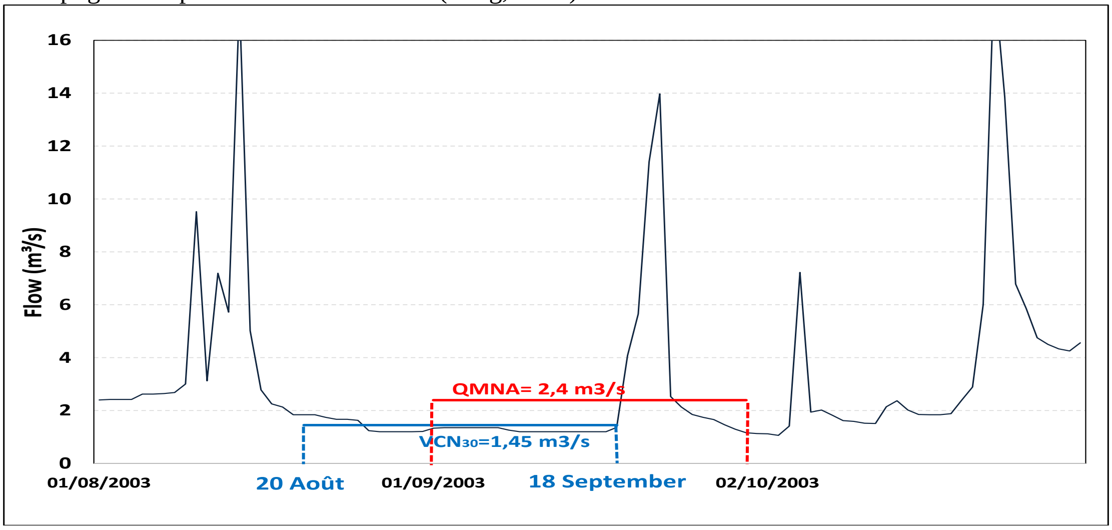

Figure 4: Comparison between QMNA and VCN_{30} - Tassaout watershed at Tamsemat station in 2003

The use of VCNd in the identification of low-flow would be appropriate instead of QMNA to limit the influence of precipitation (Lang, 2004). The need to supplement the average values determined in an arbitrary monthly framework, with average values for consecutive days, is an idea already submitted by Frecaut (1967).

The extracted variables are often used in frequency analysis, with the aim of estimating return periods based on fitted statistical laws. The determination of the theoretical distribution law, which is suitable for describing the frequency and fit of the low-flow variables, is still under discussion by many researchers, who have explained the difficulty of defining these laws in a unified and integral way. Gustard (1989) indicates that the choice of an appropriate distribution remains of relatively limited importance, given that the return times obtained in the optimal cases are relatively small (less than 50 years) compared to the length of the available record.

4.2 Low-flow indices obtained by statistical adjustments:

The frequency is analysed by fitting a statistical law to a sample of hydrological observations, to assess the relationship between the estimated flow for the return time T and the associated non-exceedance frequency. The objective is to calculate low-flow indices, and to define the mean time between the occurrence of two low-flow events (Ven Te Chow et al, 1988). To do this, probability models are used, which are mathematical formulas aimed at simulating natural hydrological events as probabilistic processes, based on the analysis of the distribution of the random variables studied. Thus, the statistical treatment of a chronicle made up of several years of flow observations will allow the frequency of these values to be calculated, to deduce the flow indicators and reduce them to a single value associated with the return period; where the QMNA, or the VCNd is adjusted according to the most appropriate adjustment law (Garcia, 2016). Low-flow flows cannot be predicted for return periods that are significantly longer than the duration of the measurements. It is therefore necessary to apply these models to a sufficiently long-time span.

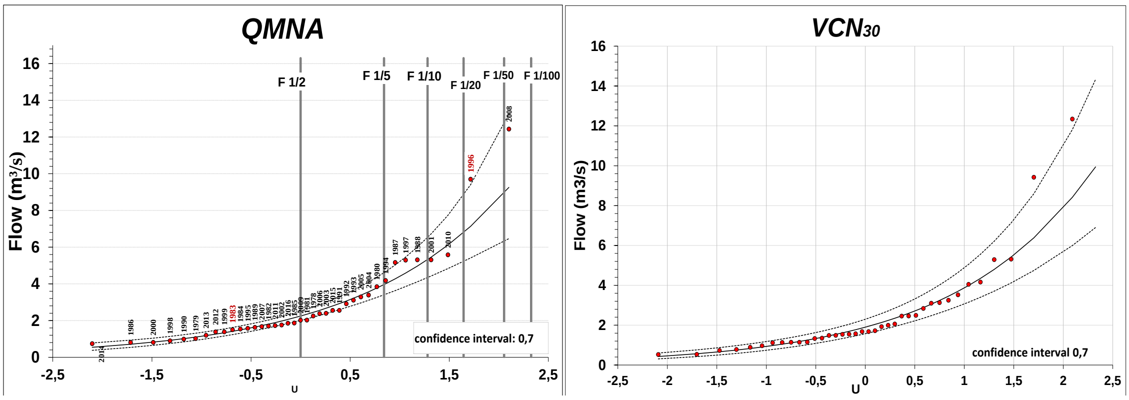

Figure 5: Adjustment of VCN_{30} and QMNA from the Tamsemat station (1976-2016) to the Log-normal law

The most important return times or periods of occurrence are of short to medium duration in the case of low-flow, with most of the studies we reviewed having no return time greater than 10 years (Gailliez, 2013). As examples, we cite:

- In America, Q7.10 and Q7.2 which correspond to the minimum of the year of the moving average of flows over 7 consecutive days with return times of 10 years and 2 years (Hamza, 1999).
- In Quebec, Q30.5 corresponds to the minimum of the year of the moving average of flows over 30 consecutive days with a return time of 5 years (Hamza, 1999).
- In France, the VCN(1,2) retained by IRSTEA corresponds to the minimum daily flow over the year for a return period of two years (Galéa et al, 1999).

3.3 Duration indices and deficits:

The low-flow rate can also be determined and analysed in terms of duration and/or deficit to define it as an event, through a threshold Q0, below which the river is low-flow (Yevjevich, 1967). Low-flow analysis based on thresholds has many advantages, the most important of which is that it considers the duration of hydrological events, unlike other variables that limit low-flow to a temporal context that will be the same regardless of the year (Lang. 2007). This technique thus makes it possible to determine, for each identified event, many characteristics, including the start (t0) and end (tf) dates of the event, its duration (d = tf - t0), or the volume deficit v in relation to the threshold (Catalonia, 2006). The difficulty of this method lies in the choice of the appropriate threshold for the low-flow and the determination of the Q0 flow starting the low-flow phase. Thus, if the threshold is low enough the flows may not reach certain low-flow levels every year. The determination of the threshold flow is generally based on the characteristic flows extracted from the curve of classified flows. The characteristic low-flow (CLF) can also be used as a threshold flow, for example, since it is an extreme value, representing the severity of low-flow (Lang, 2007).

Many authors in this field have used flow values generally corresponding to frequencies above 70-95% of the classified flow curve (Fleig et al., 2006). Another example is the work of Tallaksen et al (1997) who analysed the duration and volume of deficit by adopting three different thresholds: 50, 70 and 90%. They considered that the occurrence of droughts in some years and not in others are also important characteristics when choosing an appropriate threshold level, and that this choice is not random, but rather a function of the type of water deficit studied. In the continental context in Canada, the province of New Brunswick El-Jabi (1997) relied, in his low-flow study, on the threshold of 90% of the classified flow, through which deficit periods were extracted, and he specifies that the justification for using this threshold is based on hydrological and economic particularities.

Figure N° (6) shows the volume and duration of the deficit according to the different low-flow thresholds:

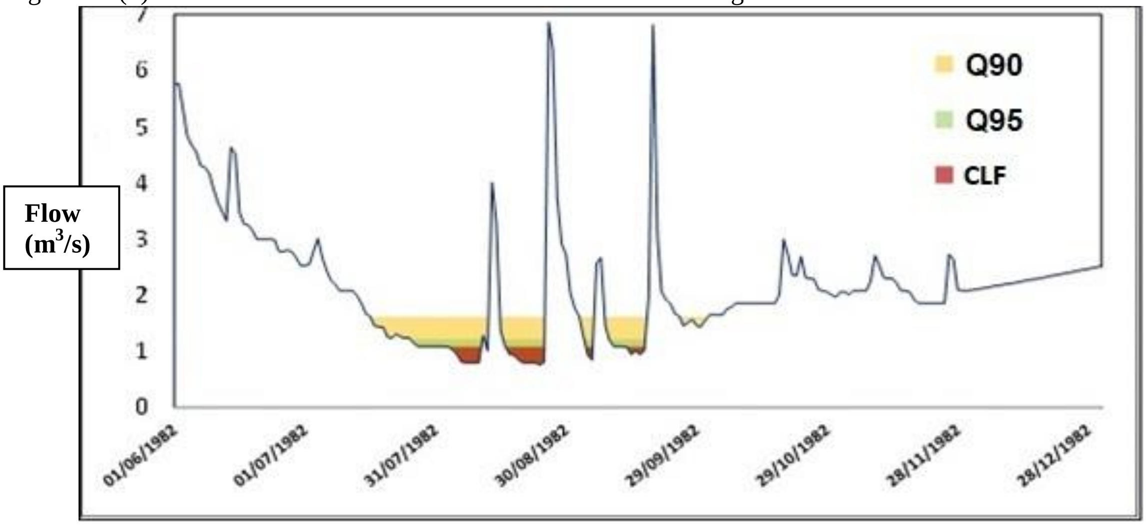

Figure 6: Detection of low-flow episodes according to different low-flow thresholds – Tassaout watershed at the Tamsemat station in 1982

Lang (2007) proposed the modal flow as the maximum threshold for limiting low-flow, which represents the daily means of the most frequent flow classes. Pardé (1963) considers that in a rainy climatic context, the typical value of the low-flow thresholds varies from 0.5 to 1.5 L/s/km2, but Lang (2007) criticised this threshold, which only expresses extreme low-flow. However, she proposes the threshold of 3 L/s/km2, which aims to set an upper limit for the identification of flows relevant to low-flow processes.

5. Low-flow regulations and management:

The regulations associated with water resource management vary from country to country. Through the different definitions of low-flow and the processes associated with it, this event can have many impacts, both on ecosystems and on human activities. As a result, many policies have been put in place to improve water resources management.

5.1 International regulatory framework for water resources management:

Until recently, low-flow issues were mainly associated with human activities, for example, drinking water supply, irrigation, energy production, tourism activities... Today, water resource management plans must also include the environmental aspect. As aquatic ecosystems are very sensitive to climate variability and drought. Anthropogenic activities (waste disposal, water abstraction) are one of the main factors that lead to the aggravation of all these phenomena.

Low-flow warning regulations have been developed mainly in Europe, as well as in the United States, Canada and elsewhere in the world, and are applied to the catchment areas most vulnerable to water deficit. These regulations are based on observed flow thresholds, through which restrictions are imposed on water use. We cite, for example, QMNA(5) for France, Q95 for Austria and Great Britain, and Q97 for Switzerland...

In the Canadian province of Quebec, for example, the winter season is often characterised by periods of low-flow, due to the accumulation of snow on the surface, and as a result, large quantities of water are retained without reaching the rivers and groundwater. Low-flow can also occur in the summer or early autumn when precipitation is scarce. The ministry assigned to this province used the variable Q7.10 (10-year return period on 7 consecutive days) as the basis for determining low-flow, as well as the variable Q30.5 (5-year return period on 30 consecutive days) (Hamza, 1999). The Montana method is also adopted in Canada, the United States of America and various countries around the world, and is a widely used hydrological method for determining ecological flow (Tharme, 2003). The instream flow, which does not exceed 30% of the mean annual flow, was considered generally appropriate for the summer period and is often the value used to protect the ecosystem (Belzile et al, 1997).

In France, the first regulations on the management of water resources were promulgated in 1992. They made it possible to recognize water resources as "common heritage of the nation". The first measures for the management and protection of water resources have been identified, through the creation of Master Plans for Water Development and Management (SDAGE) which manage the large watersheds in France, and Development and Water Management (SAGE) at the sub-basin scale (Garcia, 2016). Following the drought of 2003, the Drought Framework Plan for the improvement of water resources management was put in place in 2005, which defines four levels of intervention, to introduce different constraints according to the levels of drought. observed. These levels allow a compromise between the maintenance of ecosystems, health, and the different uses of water. The determination of these four levels is based on the low-flow indicators associated with each catchment area. The four levels are as follows (Garcia, 2016):

- **Vigilance threshold**: at this first stage, communication and awareness-raising measures to save water are taken with the various users, without however ;
- **Alert threshold**: This level is linked to the 'DOE' (Objective low-flow), which must be guaranteed statistically at least 8 years out of 10 of flow above the threshold. It must also ensure the proper functioning of the aquatic environment. At this level, the first limits on water use must be set.
- **Crisis threshold**: If the crisis flow threshold is exceeded, measures must be implemented and reinforced to reduce water abstraction operations, or even the withdrawal of certain uses, so as not to reach the reinforced crisis level.
- **Reinforced crisis level**: at this stage, it must ensure the survival of aquatic species and the supply of drinking water. Thus, complete water abstraction operations must be stopped.

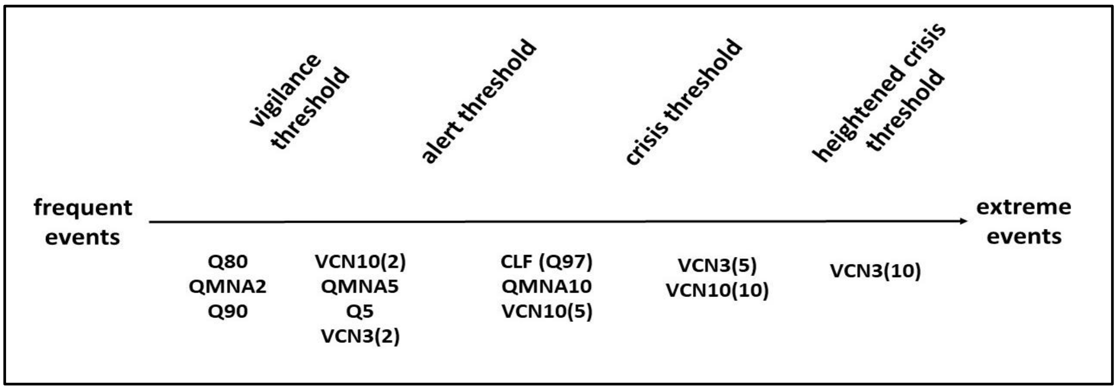

Figure 7: Statistical flow indicators suggested by Lang (2011) to determine the state of the hydrological situation during low-flow

These intervention levels have been qualitatively defined at the national level. However, the flow thresholds used for the implementation of these four levels were determined locally by the catchment area managers. Lang (2011) has worked on arranging the low-flow indicators in an incremental manner based on a statistical study. Figure (7) provides a classification of the different statistical indicators that can be used to determine the hydrological state.

5.2 Regulatory framework for water resources management in Morocco:

Crises linked to the reduction of water resources during low-flow levels can be managed by implementing regulatory measures aimed at reconciling the various uses while preserving the aquatic environment. Among the most important regulations and laws adopted at national level for water resources management we mention the Water Law 36-15, which is considered an alternative to the Water Law 10-95, the latter of which had some shortcomings and was improved in order to formulate some requirements concerning water, to clarify them and to deal with some cases of inconsistencies and ambiguities, aims to complete the water law with new legislative articles related in particular to the vulnerability of aquifers, the mobilisation and management of rainwater and the conditions of desalination of sea water, the reuse of wastewater and the organisation of drilling, and the management of extreme phenomena such as drought and floods.

As for the problem of low-flow levels and in the framework of water conservation, the water law 36-15 stipulates according to article 97 the following: "A minimum flow is maintained, according to the seasons, downstream of the hydraulic works of storage, diversion or withdrawal of water, According to article 86 of the same law, "incase of water shortage resulting from events other than drought, the administration makes known the situation of water shortage, specifies the concerned area and decides on local and temporary measures aiming at ensuring priority to supply the population with water and water the animals".

If these levels are defined "qualitatively" on a national scale, why can't low-flow values be defined precisely in a statistical sense? This choice is left to the basin managers to consider the context and local specificities (according to the abundance of water resources and the different uses).

Although there are hydrological studies on Moroccan basins that address the issue of low-flow, they have not dealt with it in a precise and detailed manner, and have been limited to specifying the thresholds for its occurrence, For example, the report on (water resources in Morocco, 1972), the first part of which included hydrological studies on the basins of Morocco, where, in its analysis of the water deficit, the characteristic low-flow (CLF) was defined as a threshold for the occurrence of this event, which refers to the flow equal to or greater than 355 days per year. We also note the study on "detection of evolutions in the hydrological regimes of the Sebou basin" which was carried out within the framework of the study programme on "climate change: impacts on Morocco and global adaptation options" in 2010, the threshold of the low-flow level was determined as a percentage corresponding to 15% of the daily flow classified in the statistical series, which corresponds to the characteristic flow Q85.

In sum, there is a lack of legislation on the management of low-flow to detect the situation of water resources. This can only be achieved through statistical studies to determine low-flow indicators and thus adjust the severity thresholds that reflect the levels of intervention to enact restrictions on water users.

6. Conclusion

The following table presents a summary of the different low-flow indicators that have been described. However, regardless of the variable specified, it seems difficult to understand the problem of low-flow based on a single indicator.

Table 1: Low-flow variables, Abi-Zeid and Bobée (1999), modified

Criterion	**Tidal Range Variable**	**Definition**
Flow duration curve	- Absolute draught - FDC - Qx	- Known minimum flow rate - Flow equalled or exceeded for 10 days per year - Flow exceeded x% of the time
Fixed duration	- QMNA - VCNd	- Minimum monthly average flow rate for the year - Minimum flow rate for the year calculated on d consecutive days
Threshold flow rate	- Volume deficit - Deficit duration	- Volume below threshold flow - Duration below threshold flow

The choice of low-flow indicators is linked to the type of study and the objectives to be achieved, and the natural and climatic characteristics of the study area. Moreover, most of the studies consulted were carried out in a moderate oceanic and humid continental context; since the flow is characterised by a significant variability throughout the year; due to the long period of precipitation and its distribution during the different periods of the year.

However, the problem that the researcher may face is the near absence of studies in semi-arid contexts, although some authors deal with the subject in part without conducting a thorough statistical analysis. Statistical analysis, based on a detailed methodology, scientifically highlights low-flow levels. Thus, a catalogue can be made through which the levels are determined quantitatively according to the climatic and natural characteristics of each catchment area.

Statistical and frequency analysis can help us to control low-flow levels. But there are other bills that affect the flow, the most important of which are the anthropic impacts that can aggravate the crisis, and sometimes exceed the effects related to the climate itself, in this case we talk about anthropic low-flow. At this point, strategies must be considered according to a coherent approach, aiming to generate a better balance between uses while maintaining the proper functioning of aquatic environments.

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