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FLOOD CONTROL RESERVOIR USING VBA SIMULATION CASE OF IDLES BASIN IN SOUTHERN ALGERIA

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ABSTRACT

Flooding risk is a contemporary concern in Algeria and worldwide, especially in light of several recent large-scale catastrophic floods in several countries. In this context, protection systems against floods are becoming increasingly necessary for all actors concerned (decision-makers and technicians).

The present work focused on a new program created in Visual Basic for Applications (VBA) to supply parameters for sizing a damping reservoir to control floods. This program will be applied to the IDLES basin in southern Algeria, where many devastating floods are known.

The chosen approach involves the selection of the most vulnerable location for the flood. These hydrological flow data have been calculated according to the empirical approach producing a higher flow rate to the maximum permitted for the streambed, where flood routing is used to size the reservoir. The current condition was added to the VBA application after choosing the most intriguing location to locate the reservoir to generate scenarios and enable the selection of an optimal situation in light of the restrictions being put forth to regulate floods in the IDLES basin.

A very acceptable and practical result is highlighted, indicating general parameters for sizing a damping reservoir to control floods in the IDLES basin; the results present a size of 2 km^2 bottom area and 7.25 m in length, which can dampen a centennial flood flow of approximately 284.22 m^3/s to 94.71 m^3/s, i.e., a depreciation of 67%.

Keywords: Flood control, Flow damping reservoirs, VBA programming, IDLES Basin

INTRODUCTION

Floods are one of the most frequent natural disasters. Global warming and human activity have increased the risk of rising sea levels and their impact (Ali et al., 2020). The size of floods is highly variable, from small local floods to large-scale disasters affecting several countries. Floods can result from different events, from heavy rains to tsunamis or a flooded river (Tarasova et al., 2019). Depending on the cause, flooding occurs suddenly or more slowly, in most cases when a river floods. Floods usually occur in coastal strips or areas near a waterway but are small (Ba et al., 2022).

Historically, in Chad 2012, Floods forced hundreds of thousands of people to flee their homes and drowned more than 250,000 hectares of arable land, forcing several hundred households from the capital N'Djamena to seek higher ground (Byun et al., 2015). Flash floods in Egypt's Wadi El Arish in January 2010 and Qena in January 2013 resulted in significant property damage and casualties (Moawad et al., 2016).

Violent floods in September 2020 ravaged nearly Sudan, claimed 106 lives, ruined thousands of hectares of land, and displaced more than 500,000 people (OCHA, 2020). Financial losses and physical destruction are typically very severe; for example, the city of Nîmes alone lost 300 million Euros in 1988, Gard lost 1.2 billion Euros in 2002 (Huet et al., 2003), and Aude lost 3.3 billion Euros in 1999 (Lefrou et al., 2000). These figures should be contrasted with the global average for insured losses attributable to natural disasters, which comes to approximately 40 billion Euros annually (Re, 2002).

In the past 20 years, devastating floods in Algeria have primarily affected the country's major cities and urban centers (Algiers in 2001, Bejaia in 2012, and most recently, Batna in 2020), resulting in numerous fatalities and extensive property damage (Zegait, 2022). These floods were mainly known as the result of large rivers that overflowed in expansive agricultural plains.

In this sense, climate change is one of the primary reasons for these catastrophic floods, as several forecasts have indicated that precipitation and temperatures in various parts of the world will certainly increase (Nouaceur et al., 2013). Therefore, the global community is now interested in climate change and its effects on water supplies due to the advent of numerous recent climatic occurrences. These include the droughts that have affected the Maghreb countries, notably Algeria, since the 1970s and are sometimes followed by devastating floods (Laborde, 1993; Meddi, 2007).

Several studies on rainfall and temperature have been conducted in Algeria's northern regions (Touitou et al., 2018). According to Bessaklia et al. (2018), the Mann-Kendall test revealed areas with increasing trends in high precipitation events in the extreme northeast of Algeria using 23 rainfall stations. Droughts appear more common in arid and semiarid regions in northeastern Algeria, whereas humid and subhumid areas receive more precipitation and consequent floods (Merabti et al., 2018). Few works in southern Algeria have analyzed the effects of climate change on water resources, except for some works (Remini, 2020) that demonstrated that it is necessary to adapt to a dry climate using traditional systems that have been in place for centuries.

Floods have historically been highly beneficial events in the Algerian Sahara, where aridity is the dominant factor (Troin, 2006) because they are the primary source of groundwater recharge along drainage basins (Remini, 2020). However, severe floods have occurred in these areas recently, causing economic losses and deaths. They are frequently the result of heavy rains, such as Tamanrasset in 2002, Adrar in 2004, Illizi in 2006, Ghardaia in 2008, El Bayadh in 2011, In-Guezzam in 2018, and Djanet in 2019. (Bachar, 2015; Bekhira, 2019; Zegait, 2021; Hafnaoui et al., 2022). These result from complex weather phenomena such as climate change and extreme violence. They are the most typical Mediterranean disasters (Ballais, 2005).

According to records, IDLES City in southern Algeria has suffered numerous significant floods (Zegait et al., 2022). Historical flood disasters worldwide and the evolution of built-up habitats in flood-prone areas are essential drivers for reducing flood risks. Our contribution fits into this context, and our thoughts are on the flood problem in Algeria.

Damping reservoirs represents one of the methods frequently used to limit flooding and sometimes has multiple vocations. Its principle of operation is to temporarily store a specific volume in the river's bed upstream to protect the downstream and reduce the flood flows downstream.

VBA (Visual Basic for Applications) applications, such as RSA (Reservoir Sizing Application), can be helpful for dimensioning reservoirs, where these applications can automate calculating the proper size of a reservoir based on specific input parameters. Using VBA applications can also help increase the efficiency and accuracy of the reservoir dimensioning process and reduce the potential for human error (Galil et al., 2021). In this context, this modest work's main objective is to dimension a damping reservoir intended to control floods in the IDLES basin using a newly developed application in Visual Basic (VBA) for Excel.

FLOOD RESERVOIR AND ROUTING

Temporary storage reservoirs are highly effective in reducing discharges in a portion of the urban drainage gallery system because they encourage the partial retention of runoff from rainfall (Luo et al., 2022). They are built interspersed in the network and store the pluvial flow during part of the concentration period of the upstream gallery, gradually discharging it in the downstream gallery, limiting the flow in this last conduit; this fact allows for the reduction of its dimensions, in the case of a project, or the attenuation of floods in more critical situations. Because of their storage capacity, reservoirs offer the most likely uniform flow, which adds to the gallery system's improved performance by minimizing the high peaks of flood waves caused by waters precipitated in heavy rain (Wilken, 1978).

As structures release collected amounts, these reservoirs frequently feature orifices or spillways. In general, orifices are used to discharge lower quantities than spillways. As a result, both structures are typically used together when designing reservoirs to manage runoff from rainfall with a recurrence duration ranging from 10 to 100 years. Smaller floods are mitigated by discharges via orifices, while severe rain triggers spillways.

Akan (1989) underlines the importance of selecting an appropriate recurrence time as a critical component for damping reservoirs to work properly. Another study in his article addresses that if a 100-year rainfall is used to dimension the detention reservoir, the effect of lowering the flood peak for considerably more minor rains will be minimal. In the other case, if a 10-year rainfall is used for sizing, the 100-year rainfall will flow through the reservoir with a discharge peak far more significant than the projected rate.

According to Abt et al. (1978), detention reservoirs should not be built arbitrarily in basins since instead of alleviating them, they might exacerbate the danger of large floods when not considering all possible impacts. To ensure optimal efficiency in the process, buffer reservoirs must be connected with contributing basins and regional strategies for controlling large flows from rainfall. Estimates of the storage volumes required to limit flood flows to desired levels are frequently required in rainfall studies. These estimations are essential in locating and assessing possible locations for detention reservoir placement (McEnroe, 1992). For the control of specifically urban floods with relatively small flows, the issue of reservoir positioning primarily consists of reconciling ideal locations conducive to optimal system functioning with areas where there is available space and topographical conditions favorable to project implementation.

In reservoirs, the procedure known as flood routing consists of computing accumulated water levels, stored volumes, and discharged flows, all of which correlate to a specific influent hydrograph, to validate the reservoir's influence in damping floods (Creager et al., 1945). When a flood wave enters a reservoir, the water level rises, increasing the amount accumulated. The discharge through orifices and weirs increases as the level rises, but not as much as the increase in influent flow. The procedure is repeated until the inflow peak is achieved, and if it remains constant for some time (which it does not owe to the form of the hydrography), the highest value of the outflow would be the same as the inflow. From then on, the inflow hydrograph drops, while the fall in the outflow is more gradual, to the point where the outflow exceeds the inflow. The reservoir temporarily stores a volume of water during the procedure. Depending on the size of the reservoir and storage capacity, the effluent hydrograph will have a much lower peak than the influent hydrograph. As a result, flood damping is characterized.

MATERIALS AND METHODS

Study Area

The study area is located in the extreme south of the Algerian Sahara at 23°48' N, 5°55' E. The IDLES city is located more than 1400 km from the capital and 280 km from the main province of Tamanrasset, administratively covering more than 54125 km^2 or 9.70% of the total area of Tamanrasset province (Fig.1). According to the different climatic parameters (1990-2020) provided by the National Meteorological Office in 2020 (temperature, rainfall, wind, evaporation, humidity, etc.), the climate is hyperarid, characterized by low rainfall and irregularity with an average of approximately 43 mm/year and high temperatures during the summer season that can exceed 35°C, while in winter, it is generally mild with average temperatures of 12-19°C. Winds are relatively frequent and irregular. Their speed is important from March to July, which causes sirocco and sand winds during this period, accompanied by a very strong evaporation rate (approximately 4911 mm/year) (ONM, 2020).

The IDLES watershed is an integral part of Tassili Hoggar, whose main features are the extent of its rocky plateaus, sporadically strewn with dunes. It is located in the **IDLES** Wadi depression area, which represents the main drain of the basin with a length of 94 km. It covers an area of 557,9 km² (Table 1). It is gradually fed throughout its course by small sources (Fig. 2). Its low flow rate is zero, despite its considerable catchment area. The watershed has a low drainage density. The value calculated according to Horton's law (1945) is 0.9, and the average slope of the watershed is 5.99%, which evokes a medium roar. The vegetation cover is almost nonexistent except for some trees at the bottom of the wadi. Runoff promotes soil stripping and the dismantling of terraces at the bottom of valleys.

Table 1: Physiographic parameters of the IDLES watershed

Watershed	A (Km^2)	P (km)	KG	Max altitude (m)	Min altitude (m)	Slope Avg (%)	Lcp (km)
IDLES	557.9	226.83	2.69	2515	1381	5.99	94.5

where A is the watershed area, P is the watershed perimeter, KG is the Gravelius index, Max altitude and Min altitude are the maximum and minimum altitudes of the watershed, respectively, Slope avg is the average slope of the mainstream, and Lcp is the mainstream length.

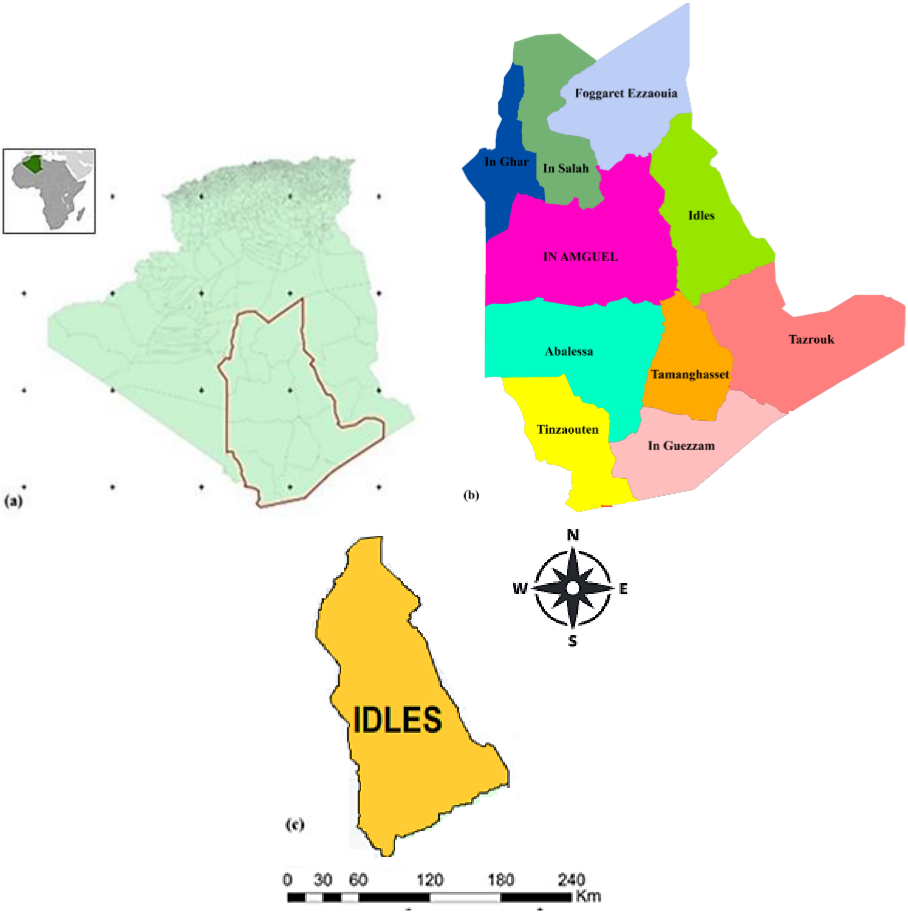


Figure 1: (a) Situation of the Tamanrasset region; (b) Situation of the IDLES region; (c) Situation of the study area

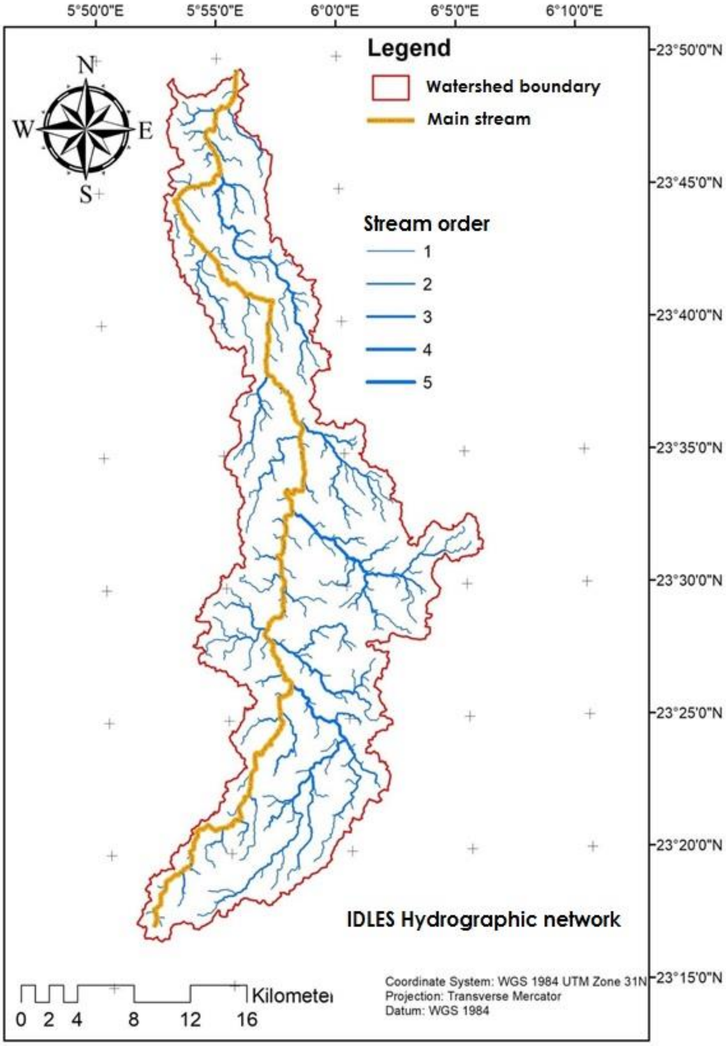


Figure 2: Hydrographic network map of the IDLES Wadi

IDLES flood history

Given the climatic conditions, no continuous measurements or observations have ever been performed on the Saharan Wadis. However, some notes have long focused on descriptive observations of floods or their traces, especially in the IDLES Wadi (Fig. 3). We have only considered floods recorded at the ONM organization due to the absence of data from the area of previous floods. The annual total varies from year to year. It occasionally rises above 100 mm, such as in 2015 (126 mm) and 2017 (102 mm) (Fig. 4). The highest 24-hour total observed to date is 38 mm, which was recorded in a short time in July 2015 and resulted in substantial damage (Fig. 5). rain usually falls in large amounts quickly in the form of showers and intense thunderstorms. The rainfall series at annual scales using the moving average method at the IDLES station has detected a positive trend (slope = +0.92 mm) over the past 3 decades (Fig. 4).

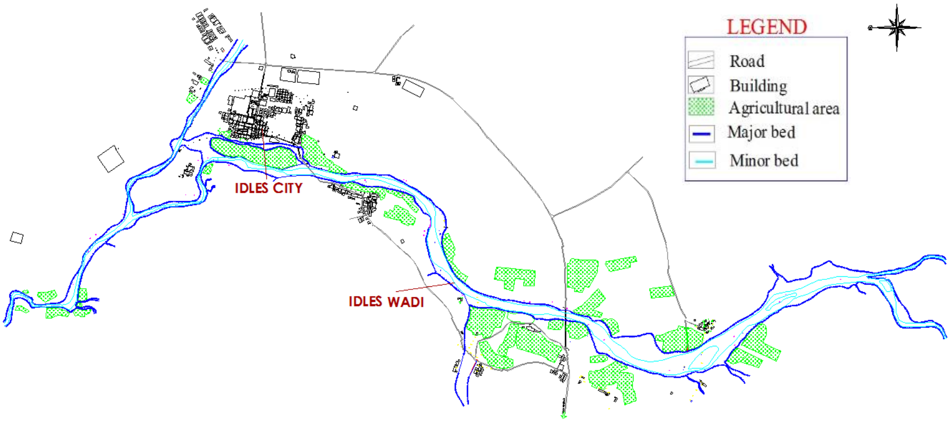


Figure 3: Watercourse at the level of the town of IDLES

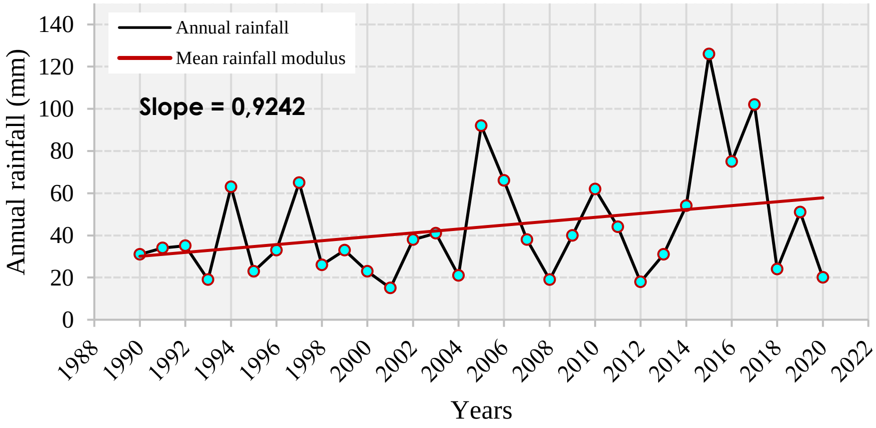


Figure 4: Chronological record of rainfall from 1990 to 2020 in IDLES

Figure 5: IDLES Wadi in dry weather and flood cases (taken by Zegait, 2020)

DATA USED

The required climatic data (Table 2) of the study area referring to precipitation were obtained from the regional meteorological station of IDLES (05°57'E, 23°49'N), established and managed by the National Meteorological Office (ONM). The 41-year time series (1980–2020) was complete without missing values; it provided daily precipitation measurements. All data sets have been georeferenced according to the UTM projection (zone 31), WGS84 Datum.

Table 2: Statistical characteristics of the data

Parameter	Min	Max	Mean	Deviation	CV
P_{Total}	15	126	42.4	19.33	0.45
$P_{d\ max}$	5.6	38.4	14.7	7.76	0.53

where P_{Total} is the total annual rainfall and P_{dmax} is the maximum daily frequency rainfall.

METHODOLOGY

The Routing Simulator Application – RSA (Galil et al., 2021; Pizzo et al., 2021) was developed in the VBA language for Excel. It was used to simulate the damping of flood flows in reservoirs, providing values of the bottom area (with the sidewalls of the reservoir always vertical) and the spillway length required for a certain damping ratio.

The RSA was conceived using flood routing theory, where the continuity equation in the reservoir, integrated by finite differences, is coupled to the flow equation in the reservoir's discharge structures, generating the routing equation. This is solved numerically and iteratively and generates, at each iteration, a new point in the reservoir effluent hydrograph.

The tributary hydrograph is adopted as triangular and discretized in sufficiently small time intervals. The ascent and descent time relationship can be arbitrated by the application user and the definition of the time interval number to obtain greater precision in the results. There is an option for discharge through bottom holes instead of a spillway. However, this was not used in the present study.

The input data to the RSA are the maximum flood flow rate at the outflow of the IDLES town watershed (understood as the maximum inflow of the reservoir) and the respective concentration time, the bottom reservoir area, and the length of the reservoir spillway. The output data are the maximum flow rate discharged by the reservoir (and its respective hydrograph) and the maximum water level reached above the spillway sill. In most situations, its use leads to a trial process, considering that the search variable is usually the maximum flow rate discharged by the reservoir (which is output from the application). In general, the one supported by the drainage system is already implemented in the downstream region.

For each return period, precipitation amounts corresponding to a short duration (less than 24 h) are established by Eq. (1) developed by Body (1985) at the request of the National Hydraulic Resources Agency (NHRA).

$$P_t = \mathrm{P}_{\mathrm{dmax}}\left(\frac{t}{24}\right)^b \qquad (1)$$

where t is the concentration-time in hours, P_{dmax} is the maximum daily frequency rainfall, and b is the climatic exponent.

Due to the type of infrastructure intended, recurrence intervals of 100 years and 40 years were adopted. Thus, different empirical formulas computed peak flows for the IDLES watershed (Mallet-Gauthier, Turazza, Giandotti, and Sokolovsky). The Sokolovsky formula Eq. (2) was selected because it considers all the watershed's characteristic parameters.

$$Q_{\max,\, p\%} = 0.28\frac{X_{p\%tc}\,\alpha_{p\%}\,S\,f}{t_m} \qquad (2)$$

where t_m = concentration time t_c of the watershed in hours, S is the area of the catchment area in square kilometers, f is the shape coefficient of the flood, and $X_{p\%\ tc}$ is the precipitation in millimeters, with probability $p\%$ corresponding to time t_c.

Several formulas were analyzed to define the concentration time of the hydrographic watershed as a function of its restrictions and adaptations to the situation of IDLES. The

Dooge formula (Almeida et al., 2014; Silveira. 2005), developed with data from rural basins of 145 km^2 to 948 km^2, was chosen and is expressed in the following equation:

$$t_c = 0.365A^{0.41}S^{-0.17} \tag{3}$$

where t_C is the concentration-time in hours, A is the area of the watershed in square kilometers, and S is the mean steepness in meters by meter.

RESULTS AND DISCUSSION

IDF curves

Creating intensity-duration-frequency (IDF) curves is the primary goal of precipitation analysis. The IDF curves are plotted for the different return periods of 5, 10, 20, 40, and 100 years (Fig. 6). The IDF curve is used to select the level of precipitation. These curves are created by fitting the maximum daily precipitation intensities for given periods to a lognormal probability distribution using the point precipitation data that were gathered locally. Typically, this is done by charting the data on a normal-value probability paper (McKay, 1970).

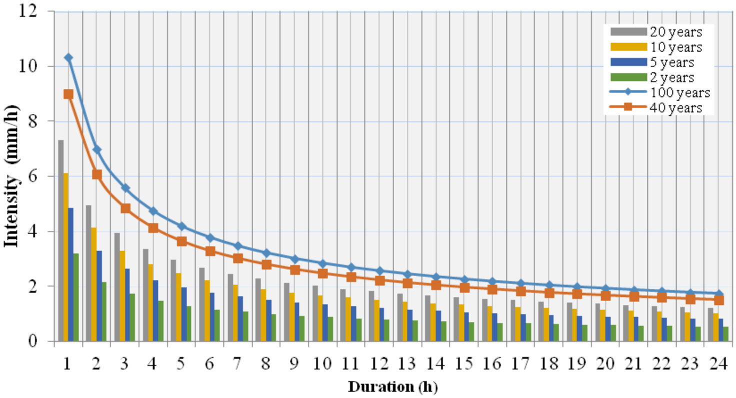


Figure 6: IDF curves for rainfall data at the IDLES Basin

Concentration Time/Flow Rates

The concentration time of the IDLES watershed was estimated to be 07 hours and 52 minutes. It can be noted that this concentration time is relatively high, which can be explained by the elongated shape of the watershed and the low slopes that reign there.

The study of floods requires understanding surface runoff patterns in the area. Quantifying the flow rates is challenging due to the poor quality of the observed data (unavailable, discontinuous, and accompanied by measurement or data input errors).

In this regard, using empirical formulas that can transform rainfall into runoff through the morphological characteristics of watersheds is among Algeria's most widely used methods.

The flows selected from the analysis and the comparison of the flows calculated by the various methods (Mallet Gauthier, Turazza, Giandotti, and Sokolovsky) are summarized in Table 3.

Table 3: Flow rates estimated by different regional methods

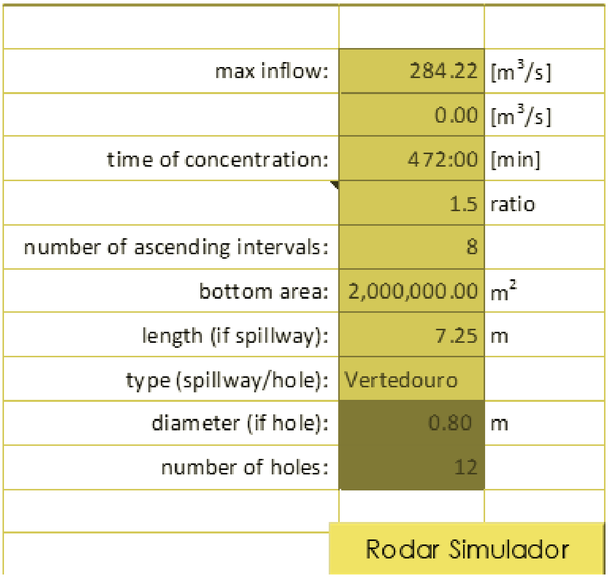
Return period	**Mallet Gauthier**	**Turazza**	**Giandotti**	**Sokolovsky**	**Average**
Year	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
100	230.85	164.89	435.14	284.22	278.77
40	207.43	134.83	379.52	232.40	238.54
20	171.65	101.97	307.54	175.77	189.23
10	138.58	79.58	258.47	137.17	153.45
5	94.56	58.58	206.12	100.97	115.06
2	-	31.77	134.14	54.76	-

The results of the Sokolovsky formula Eq. (2) can be chosen because this formula considers all the characteristic parameters of the watershed. However, the results of this formula are very close to the recorded flow in the old floods of the Saharan Wadis around the region (ABHS, 2006). The peak flow of the IDLES basin using the Sokolovsky formula was estimated to be 284.22 m^3/s and 232.40 m^3/s for return periods of 100 years and 40 years, respectively.

Sizing of the Damping Reservoir

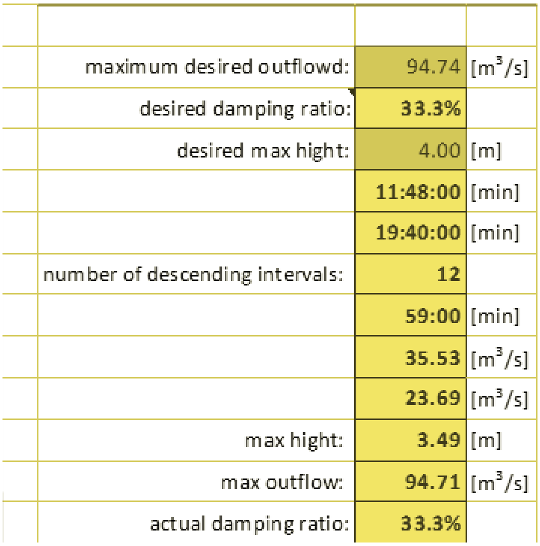
Without more accurate data related to the given region, working with damping ratios of 1/3 in such control reservoirs is quite common. Therefore. The reservoir must have dimensions such that it produces maximum effluent rates of 94.74 m^3/s and 77.47 m^3/s, corresponding to one-third of the calculated flows for recurrences of 100 years and 40 years.

Thus, it was a matter of testing several combinations of "bottom area" versus "spillway length" in RSA that would provide such damped flows. Fig. 7 illustrates one such combination for a 100-year recurrence interval, where the maximum flow of 284.22 m^3/s must be damped to 94.74 m^3/s. In the present case, a reservoir with a bottom area of 2.0 km^2 and a weir length of 7.25 m was reached. Its discharge flow rate is 94.71 m^3/s, a value immediately lower than the allowed value (94.74 m^3/s) for variations up to one-hundredth of a meter in the spillway length tests. The cells in Fig. 7 receive user input data, while the last three cells in Fig. 8 provide output data.



max inflow:	284.22	$[m^3/s]$
	0.00	$[m^3/s]$
time of concentration:	472:00	[min]
	1.5	ratio
number of ascending intervals:	8	
bottom area:	2,000,000.00	m^2
length (if spillway):	7.25	m
type (spillway/hole):	Vertedouro	
diameter (if hole):	0.80	m
number of holes:	12	

Figure 7: RSA input data for damping flow for IDLES



maximum desired outflowd:	94.74	$[m^3/s]$
desired damping ratio:	33.3%	
desired max hight:	4.00	[m]
	11:48:00	[min]
	19:40:00	[min]
number of descending intervals:	12	
	59:00	[min]
	35.53	$[m^3/s]$
	23.69	$[m^3/s]$
max hight:	3.49	[m]
max outflow:	94.71	$[m^3/s]$
actual damping ratio:	33.3%	

Figure 8: RSA output data for damping flow for IDLES

Table 4 and Fig. 9 present the RSA output data in tabulated and graphical form, respectively.

Table 4: RSA tabulated output screen for the IDLES situation

Time Interval	Accumulated period (s)	Interval period (s)	Initial inflow (m^3/s)	Final inflow (m^3/s)	Initial outflow (m^3/s)	Initial volume (m^3)	Final volume (m^3)	Final outflow (m^3/s)
1	3540	3540	0.00	35.53	0.00	0	62 741	0.08
2	7080	3540	35.53	71.06	0.08	62 741	250 114	0.64
3	10620	3540	71.06	106.58	0.64	250 114	559 599	2.15
4	14160	3540	106.58	142.11	2.15	559 599	987 088	5.03
5	17700	3540	142.11	177.64	5.03	987 088	1 527 020	9.67
6	21240	3540	177.64	213.17	9.67	1 527 020	2 172 561	16.42
7	24780	3540	213.17	248.69	16.42	2 172 561	2 915 812	25.52
8	28320	3540	248.69	**284.22**	25.52	2 915 812	3 748 046	37.20
9	31860	3540	284.22	260.54	37.20	3 748 046	4 558 118	49.89
10	35400	3540	260.54	236.85	49.89	4 558 118	5 241 305	61.52
11	38940	3540	236.85	213.17	61.52	5 241 305	5 802 132	71.65
12	42480	3540	213.17	189.48	71.65	5 802 132	6 246 341	80.03
13	46020	3540	189.48	165.80	80.03	6 246 341	6 580 353	86.54
14	49560	3540	165.80	142.11	86.54	6 580 353	6 810 888	91.12
15	53100	3540	142.11	118.43	91.12	6 810 888	6 944 683	93.82
16	56640	3540	118.43	94.74	93.82	6 944 683	6 988 291	**94.71**
17	60180	3540	94.74	71.06	94.71	6 988 291	6 947 938	93.89
18	63720	3540	71.06	47.37	93.89	6 947 938	6 829 422	91.50
19	67260	3540	47.37	23.69	91.50	6 829 422	6 638 055	87.68
20	70800	3540	23.69	0.00	87.68	6 638 055	6 378 611	82.59
21			0.00		82.59			

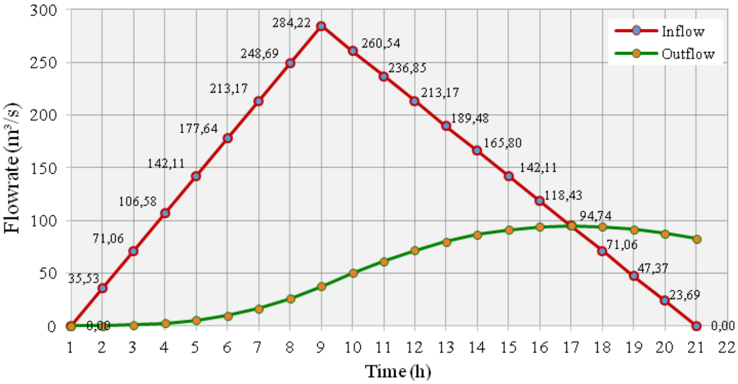


Figure 9: Graph for damping analysis

Five situations were combined for each of the 02 recurrence intervals contemplated in this study, generating 10 situations that answer the question of the desired damping for the IDLES situation. These are systematized in Table 5.

Table 5: Possible arrangements to size a damping reservoir for IDLES town

Imax	Qmax	Qmax’	BA	SL	Hmax
284.22	94.74	94.63	1.0	2.56	6.99
284.22	94.74	94.72	1.5	4.71	4.66
284.22	94.74	94.71	2.0	7.25	3.49
284.22	94.74	94.69	2.5	10.13	2.80
284.22	94.74	94.71	3.0	13.32	2.33
232.40	77.47	77.36	1.0	2.83	5.72
232.40	77.47	77.46	1.5	5.21	3.81
232.40	77.47	77.45	2.0	8.02	2.86
232.40	77.47	77.46	2.5	11.21	2.29
232.40	77.47	77.44	3.0	14.73	1.90

Imax is the maximum inflow (m^3/s), Qmax is the maximum allowable outflow (m^3/s), Qmax’ is the actual maximum outflow (m^3/s), BA is the reservoir bottom area (km^2), SL is the spillway length (m), and Hmax is the maximum height reached by the water from the spillway sill (m).

Analyzing the results shown in Table 5, it can be seen that to obtain the same damping percentage, the greater (or smaller) the area of the reservoir bottom, the greater (or shorter) must also be the length of its spillway.

Such a relationship can be physically well assimilated, as the bottom reservoir area distributes the temporal inflow volume, causing the water depth to increase more slowly. In other words, the larger the area, the smaller and slower the rise in the water depth, and the smaller and slower the increase in the effluent flow, meaning greater retention. On the other hand, the greater the length of the spillway, the greater the effluent flow, seen as a reduction in the "barrier" that "holds" the passage of water (which can be imagined as an orifice without the top). In this case, greater length proves to be unfavorable to retention. This reasoning leads to the conclusion that a factor favorable to retention must be balanced with a factor contrary to retention, as different combinations between these two factors lead to the same damping.

The bottom reservoir area and weir length data, shown in Table 5, are related and are graphically expressed in Fig. 10.

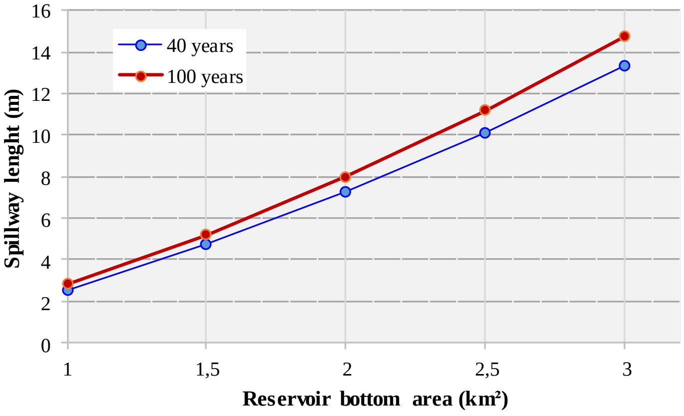


Figure 10: Bottom area versus spillway length ratio for IDLES

It is interesting to note that although many combinations can satisfy the solution to the problem, which is to dampen the flow to one-third of the original peak, the result presented here was restricted to only a few combinations because of the interest in obtaining more viable heights. In any case, the reservoir in all situations presented had a very large bottom area (Fig. 11). This fact was due to the very high concentration time, given the proportions of the contributing watershed. Thus, extremely large accumulation volumes were required for the entire period until the outflow became higher than the inflow, causing the water level to drop and keeping the water level at acceptable values.

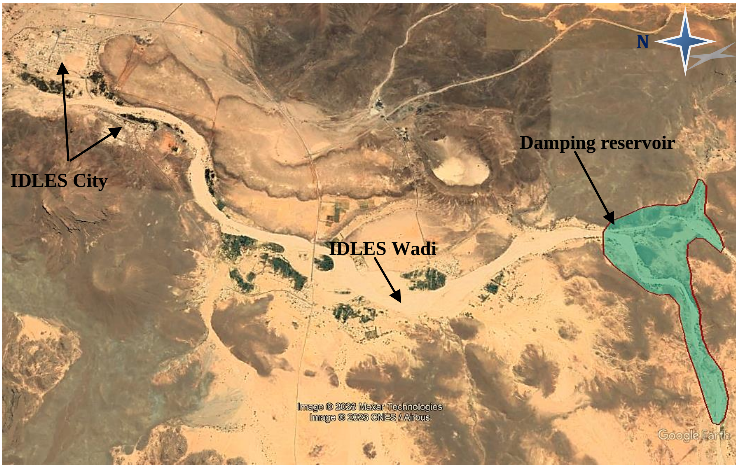


Figure 11: Projected damping reservoir location

CONCLUSION

Floods and overflows impact urban transport and infrastructure, as well as the presence of waterborne infections and the spread of vectors. They also have environmental consequences, such as contaminating urban water sources and lowering quality. Floods, in more extreme cases, cause critical factors, culminating in the loss of human life. An incessant search for new technical solutions for improving society is imperative. Land and its positioning must be well selected, and appropriate circumstances, materials, and plans must be correctly defined, in addition to the adequate and practical design of solutions, cost minimization, and full attention to environmental issues.

A study was presented to reduce the tributary flows to IDLES city in Algeria and prevent flooding. Through a VBA application based on the flood routing method, several combinations among dimensions were simulated to size a possible and viable damping reservoir to be placed upstream of the site. Some of these combinations, the most feasible in terms of reservoir measurements, are related.

The results showed that relying on this program RSA (Reservoir Sizing Application) in Visual Basic for Applications (VBA) is beneficial and helpful in dimensioning reservoirs. These applications can help increase the efficiency and accuracy of the reservoir dimensioning process and reduce the potential for human error based on specific input parameters. The results also revealed the possibility of projecting a damping reservoir with an area of 2 km^2 and a spillway length of 7.25 m built from local materials to protect IDLES city against floods, which can reduce a centennial flood flow of approximately 284.22 m^3/s to a 94.74 m^3/s flow rate, i.e., a reduction of 67%. The investigations have led to depositing this reservoir in a very suitable place 7 km from the city. Using this water to irrigate agricultural lands and surface aquifer recharge is recommended.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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