International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

Generation of Synthetic Design Storm Hyetograph and Hydrologic Modeling under HEC HMS for Ziz Watershed

Ismail Elhassnaoui, Zineb Moumen, Issam Serrari, Ahmed Bouziane, Driss Ouazar, Moulay Idriss Hasnaoui

Abstract*: This article proposes a methodology for generating hourly rainfall from daily rainfall data. It was evolved as a tool for managing flood risks on Ziz catchment, by means of Intensity-duration-frequency curves (IDF) and designed hyetograph of Chicago. The study area is located in the south-eastern part of Morocco, and did not have a monitoring station for hourly rain measure, the methodomogy consist of determinating the rainfall intensity for 24 h using IDF, then estimating the hourly rainfall using Chicago formula, in order to assess the accuracy of the method the resulting hyetographs was introduced into the semi-distributed hydrological model HEC HMS to simulate hourly flow, which was compared to the observed one. The obtaining results exhibit that the observed value is positively correlated with those obtained by the above method, as shown by the correlation coefficient and the Nash-Sutcliffe. This approach can deal with instantaneous water management issues by tackling flood risks and providing an appropriate range of data for the dam's management.

***Index Terms*: chicago rainfall, Gumbel distribution, HEC HMS, IDF curves, SCS curve number, Ziz watershed.**

I. INTRODUCTION

In contemporary society, water is facing a set of drawbacks from the excessive use and groundwater depletions to climate change and pollution, the population growth rises the stress, especially in developing country. According to the 6th report of the intergovernmental panel on climate change, Morocco is one of the country the most vulnerable to climate change impact, a diminution of up to 20% in rainfall is predicted by the end of this century, and the increase in temperature is expected to reach 2.5 °C to 5.5 °C under the same scenario, the 2014 report indicate also that the availability of water has decreased from 3500m3/person/the year 1960 to 1000m3/person/year in 2000, a drop of 420 m3/person/year in 2020 is predicted, introducing a rising water demanded in the future. Dam's policy and green morocco plan help the country to overcome some of the issues related to water supply and food security, However, it still facing problems, since the stress is still increasing, also the drip irrigation doses not assure a strong production growth[1], [2], especially in region located in the south eastern part of the country where the climate is arid and the water distribution during the year is not balanced.

Ziz watershed is located in this area, receiving less than 200 mm of precipitation per year, the basin did not evade the impact of the cited issues, hydrologic cycle did not assure a complete renew because of high evaporation rate. The HASSAN ADD-AKHIL dam was constructed for flood management and agricultural water supply, but did not guarantee a good water management. To address this issue, the presented article aims to provide a complete methodology for generating hourly rainfall in the light of the absence of instantaneous observed data, the resulting data are introduced in the hydrologic model HEC HMS to simulate the flow in the outlet of the watershed, and then provide data that help manager and decision makers to adopt the plausible management strategies, and help the ecosystems to build a strong resilience capacity against climate change and natural hazard risks. It is important to mention that no previous study about hydrologic modeling was carried out on Ziz watershed, thus the presented article will serve as a reference for future studies. The first part of this paper highlights a literature review of the probability distribution, the designed hyetographs and the hydrological models, in the purpose of providing clear grasping of the concept. The second part is focused on the generation of designed hyetographs from Chicago rainfall formula, and the hydrologic modelinh using HEC HMS. The last section is dedicated to the presentation and the discussion of the results

Manuscript published on 30 August 2019.

*Correspondence Author(s)
Ismail Elhassnaoui, Mohammadia School of Engineers, University Mohammed V,Rabat-Morocco.
Zineb Moumen, Department of Geo-resources and Environment, University of Sidi Mohammed Ben Abdellah / Faculty of sciences and technologies, Fez, Morocco.
Ahmed Bouziane, Mohammadia School of Engineers, University Mohammed V,Rabat-Morocco.
Driss Ouazar, Mohammadia School of Engineers, University Mohammed V,Rabat-Morocco.
Moulay Driss Hasnaoui, Water resource departement, the Ministry Delegate to the Ministry of Energy-Rabat Morocco

II. LITERATURE REVIEW

A. Generalities

The hydrologic process varies according to a set of quantified parameters such as climate, soil properties, land use… The process could be predictable and also random. For random variation, the data observed in a specific point and time is independent than the other observations, then, they could be treated statistically [3].The stochastic description of rainfall data provides a decent stepping stone for the prediction of extreme events. In 1914 Hazen proposed a method for flood peaks analysis, 14 years later, Fisher and Tippett studied the probability of extreme values distribution, which are respectively named type I, II, and III, the propriety of the first distributions (type I) were developed by Gumbel in 1941, who introduced the extreme value law for hydrologic frequency analysis, and the return period notion. Chow et al (1988) link the extreme events occurrence with the probability distribution, while Cunnane (1988) suggest twelve methods of flood frequency analysis[4] The literature underlines two approaches of frequency analysis; the Annual Flood Series (AFS), and the Peaks Over Threshold (POT), a detailed description of the two methods is presented by B. Bobée et al, in the study of comparison between two distributed approach for frequency analysis [5].

B. Probability of distribution

According to van the chow *the probability of distribution is a function exhibiting the probability of occurrence of a random variable by fitting a determined distribution to hydrologic data rang*, For instance, considering a range of precipitation data, the probability of distribution is the likelihood that a random variable appertaining to the concerned hydrological dataset may lie in a determined range[3]. There are plenty of probability distribution functions that were formalized through the last century, the frequently used are; the Normal distribution evolved first by Horton in 1913, and modified by Chow in 1954, Exponential distribution (Kavvas and Delleur, 1981; Waymire and Gupta, 1981), Gamma distribution (Abramowitz and Stegun, 1965), Log Pearson Type III (Beard 1962), Extreme Value distribution I Gumbel (1941), II Frechet (1927), and Weibull (1939) for Type III.

In order to measure how well the probability distribution is fitting the data range, the below test could be applied: Kolmogorov-smirnov, Anderson-Darling and Chi square[4].

C. Rainfall Intensity-Duration-frequency method

Rainfall intensity–duration–frequency curves describe rainfall intensity as a function of duration for a given return period [6], [7]. Chow, 1964 underlines the relation between the Intensity, Duration, and Frequency of rainfall. The intensity is the magnitude of rain amount per unit time generally measured in mm/h, in other terms, it is the ratio between the precipitation expressed in millimeter and the duration in an hour. The frequency is the inverse of the return period, which is the time length of re-occurrence of a specific amount of rainfall (2,5,10,25,50,100,200 years…), for a continuous period of time these curves give the probability for which the intensity exceeds the threshold intensity [8]. IDF curves are obtained by applying the frequency analysis on a rainfall series, then fitting a probability distribution method such as the Montana [3] commonly used in real study cases [9],The times equation evolved by the Spanish Water Authority, and the method of maximum likelihood. The above-mentioned method, could be used to develop the design hyetograph and estimate the peak flow of a hydrologic series, they are widely used for flood control, dam and bridges construction and management [10] by means of hydrological and hydraulic modeling.

The IDF curve method has gained a large prominence through different study all over the world (e. g. Jakob et al., 2007; Xu and Tung, 2009; Lee et al., 2010; Haddad et al., 2011; Dourte et al., 2013; Du et al., 2014), they were applied on Yangambi station in Congo, using precipitation series in conjunction with Montana method, the results uncovered advantages and the inconvenient of the classical Montana formula, which did not lead to a satisfying result regarding the probabilistic and physical-based approach[11]. Further a study carried out in the south of Quebec, compared two different estimators of IDF curves, using the partial duration series (SDP) and the series of annual maxima (SMA) [12], Another study was performed in Brazil, aims to analyze the temporal distribution for intense rainfall and develop an IDF equation [13]. Munshi Md. Rasel and Sayed Mukit Hossain (2015) evolve IDF empirical equation for Bangladesh, using a data for 41 years, in order to measure the rain intensity for any duration or return period, then predict future climate fluctuations, the authors used Gumbel method for data distribution, the results figure out that the probability of occurrence of high-intensity rain for a specific duration is inferior to the occurrence of lower intensities[14], the aforementioned method was also accomplished is Surat city of India with a view to use it in the design of urban drainage patterns, drainage water sink, and hydraulic constructions [15], In Saudi Arabia Al-Anazil and El-Sebaie (2013) applied IDF relationships for Abha, by using Gumbel, Log normal and Log Pearson Type III distributions for six different frequency period. Al-Shaikh (1985) carry out distribution with the maximum likelihood method in four regions in Saudi Arabia and generate the IDF curves.

D. Designed storm hyetographs

Due to the lack of rainfall data, hydrologist referred to design storm hyetograph to process the rainfall-runoff modeling, they are used to distribute rainfall intensity per time unit. Hourly rainfall data has a crucial interest in term of the flood mitigation, Inundation control, water management, design and control of hydraulic constructions. The models used for hyetograph generation vary according to the variables describing the precipitation behavior [16]. The bench-scale research about design hyetographs exposes that the rectangular form established by the rational method is the most prevalent [17], this method formed the launched pad of others, which aims to improve the estimation of the distribution of the rainfall during a precipitation event. For instance, the variational method [18], triangular hyetograph [19] the approach proposed by sifalda in 1973 [20], the best linear unbiased estimation (BLUE) hyetograph [21] the Chicago hyetograph [22], Grimaldi and Serinaldi used a multivariate approach for analyzing and estimating the proprieties of rainstorms [23], Lin et al. (2009) propose other approach based on self-organizing map (SMO) method to establish design hyetograph in an ungauged station[24].

Furthermore, the broad range of the cited models often creates confusion about which one is the most suitable for specific study case, *Lorenzo Alfieri, Francesco Laio and Pierluigi Claps* analyze five different hyetographs and specify the patterns of their variation [18].

III. STUDY AREA AND DESCRIPTION OF USED DATA

This study is carried out on Ziz catchment located in the south-eastern part of Morocco between latitudes 29°30 'and 32°30'[25], Ziz Ghriss river channel drains an area of around 40 Km² from the north to the south, the minimal elevation is 580 masl and the maximum is 3450 masl.

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

The intermittent streams of the studied river feed the a part of the Errachidia groundwater [25], the area has a semi-arid climate.

The presented study requires two types of data:

Gis data

-The digital elevation model (DEM) was download from the Shuttle Radar Topography Mission (STRM) available in **http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp.** the raster has the following Characteristics

Table I: DEM Characteristics

Source: *http://earthexplorer.usgs.gov/*

Acquisition date	Sensor	Spatial resolution	Radiometric resolution
17/10/2017	STRM	30 m	16 bits

It is used in hydrologic modeling to delineate the sub-basin, to calculate the topographic parameters of the watershed (slope, reach, longest flow path).

-The land Use and soil maps were extracted from land cover map (European Space Agency Project), these maps will be used for the estimation of the curve number parameter.

The hydroclimatic data

The hydroclimatic data were provided by the watershed hydraulic agency of Ziz, the daily maximum rainfall data were obtained from the recording of the rain stations of Zaabel and Foum Tillicht for a period of 12 years (1982-1993), the flow discharge used for the calibration is recorded by the station of Foum Zaabel and Foum Tillicht for the same period.

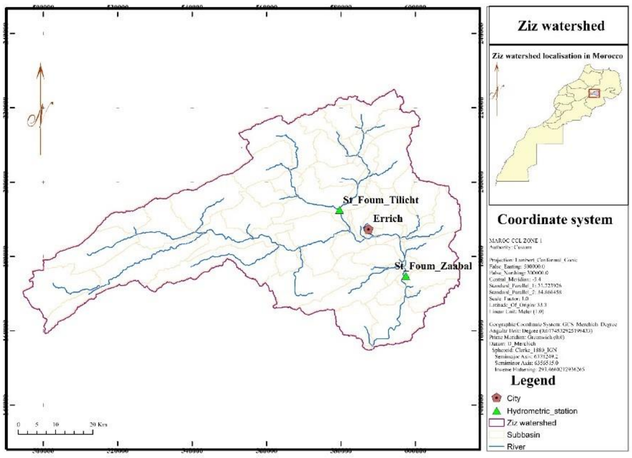

Figure 1: Geographic situation of Ziz watershed

IV. MATERIALS AND METHODS

This part is dedicated to present the followed methodology for the estimation of hourly rainfall from IDF curve and the hydrologic modeling components.

A. Gumbel distribution

The estimation of hourly rainfall starts by the frequency analysis, which aims to determine the peak rain corresponding to variant return period. The frequency analysis includes the identification of dataset, the choice of the probability distribution, the estimation of the parameters of the probability distribution function and the correspondents' quantiles for each return period.

Note to mention that the characterization of extreme events follows generally two approaches;

The two differents approaches are generally used to estimate the quantiles of events intensities; the annual maximum series (AMS), and the partial duration series (PDS), the first method uses the maximum value of a series recorded for a specific period of time (1h, 12h 24h..) [12] and it is used with the generalized extreme value distribution method. The SDP approach, consists in selecting the data above a determinate threshold [12], this later is less common because first, it is difficult to select the appropriate threshold, second the statistic independence of the selected data is not always evident, a detailed comparison between the two approaches is given in *Madsen* paper [26].

Gumbel distribution is obtained from the General Extreme Value (GEV), it was chosen for this study because of its adequacy to arid and semi-arid climate context [6], [7]. In general Gumbel distribution has two main parameters, the first one is a, related to the form of distribution and present the slope of the Gumbel graph, the second is b and related to the position according to the reduced variable u.

The GEV function formula is:

$$F(x) = \exp\left[-\left(1 - k\frac{x-a}{b} \right)^{\frac{1}{k}} \right] \quad (1)$$

For $k = 0$;

$$F(x) = \exp\left[-\exp(-\frac{x-a}{b}) \right] - \infty \le x \le +\infty \quad (2)$$

Where F is the probability distribution, the reduced variable of Gumbel u is a linear function expressed as follow

$$u = \frac{x-a}{b} \quad (3)$$

Where a is the mode of distribution

$$a = \bar{X} - b\gamma \quad (4)$$

In order to define the value of those parameters the literature propose two method, the first one is a graphic determination, the second one is the Moment method firstly developed by *karl person* in 1902 [3]. According to this method;

γ is the Euler constant and equal to

$$\gamma = 0.5772$$

And;

$$b = \sqrt{\frac{6}{\pi}}\theta$$

where θ is the standard deviation and $\bar{X}$ is the arithmetic average of the data set. The detailed description of the formula (1), (2), (3) is given by Van Te chow in the Handbook of hydrology [3]. For Gumbel distribution the Hazen formula is used as a repartition function, its expression is:

$$F(X_i) = \frac{(r-0.5)}{n} \quad (5)$$

Where X_i is the variable, r is the rank, and n a number of observations.

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

B. Intensity-Duration-Frequency curves

A series of daily maximum precipitation from 1983 to 1992 of Foum Zaabel and Foum Tillicht gauged station were selected, to apply the above procedure. The maximum daily rainfall was set in ascending order for the whole duration, a rank r is attributed to each value, calculating the empiric frequency according to Hazen formula (5), the reduced variable u of Gumbel statistical distribution, and then estimating the quantiles a and b corresponding to the linear equation using the *moment* method (Table1).Once the quantiles are defined. The IDF could be fitted there are several methods proposed by some authors such a Van te chow, Bell and Chen, [27], [28] and [29], but the frequently used is Montana curves expressed as follow;

$$I_{mm} = a \times t^{b} \quad (6)$$

Where, a and b are the adjusted parameters determinate statistically from Gumbel distribution, they are respectively the Gradex and the parameter of position, t the rainfall duration in an hour and I_{mm} is the rainfall intensity estimated in mm. This method exhibits some constraints for outlying the short term storm (less than 1 hour) [9], but since the objective of this study case is the simulation of the hourly storm, the Montana method is plausible. From the equation (6), the analytical intensity of the maximum rainfalls for each duration and return period was calculated, The values are shown in (Table II and Table III) TableII: The estimated precipitation for the period of return (2, 5, 10, 20, 50, 100 years) obtained from Gumbel distribution for Zaabel gage station.

TableII: the rainfall intensity for a storm duration from 24h to 240 h for different return period (2, 5, 10, 50, 100 years) estimated using Montana formula for Foum Zaabel gage station.

t	2 years	5years	10years	20years	50years	100years
24	1,15849286	1,42566541	1,60255688	1,77224	1,991867	2,15645
48	0,76865624	0,94811348	1,06692978	1,1809	1,328426	1,438974
72	0,54630311	0,67518354	0,76051359	0,84236	0,948311	1,027704
96	0,4221345	0,52183046	0,58783786	0,65115	0,73311	0,794524
120	0,34629688	0,42709073	0,4805833	0,53189	0,598312	0,648082
144	0,29909415	0,36725846	0,41238917	0,45568	0,511715	0,553705
168	0,25922596	0,31904299	0,35864707	0,39664	0,445809	0,482658
192	0,23239365	0,28707892	0,32328534	0,35802	0,40297	0,436657
216	0,21260933	0,2623206	0,29523378	0,3268	0,36767	0,398293
240	0,19596604	0,24065706	0,2702464	0,29863	0,335368	0,362898

TableIII: the rainfall intensity for a storm duration from 24h to 240 h for different return period (2, 5, 10, 50, 100 years) estimated using Montana formula for Foum Tilicht gage station.

t	2 ans	5 ans	10 ans	20 ans	50 ans	100 ans
24	0,85993385	1,022839412	1,13069707	1,23416	1,368075	1,468427
48	0,52714368	0,631820449	0,70112558	0,7676	0,853655	0,918138
72	0,37361012	0,451551378	0,50315527	0,55265	0,616727	0,66474
96	0,29506299	0,357799896	0,39933719	0,43918	0,490754	0,529401
120	0,2443534	0,296146315	0,33043773	0,36333	0,405908	0,437813
144	0,20783643	0,252297466	0,28173454	0,30997	0,346521	0,37391
168	0,18080196	0,218867931	0,24407092	0,26825	0,299539	0,322988
192	0,16829676	0,205692883	0,23045237	0,2542	0,284944	0,307981
216	0,15173279	0,184697846	0,20652358	0,22746	0,254559	0,274866
240	0,14542427	0,174080944	0,19305416	0,21125	0,234811	0,252464

C. Chicago rainfall

The generation of hourly artificial rainfall hyetograph was processed by means of Chicago rainfall method, this later was evolved by Keifer and chu 1975 by combining two analytical equation, one describing the before the peak (7) flow and another after (8)[30]:

$$i(t,T) = \frac{a\left[\frac{t_1}{\gamma}(1-n)+b\right]}{\left(\frac{t_1}{\gamma}+b\right)^{1+n}} \quad (7)$$

$$i(t,T) = \frac{a\left[\frac{t_1}{1-\gamma}(1-n)+b\right]}{\left(1-\frac{t_1}{\gamma}+b\right)^{1+n}} \quad (8)$$

Where i is the rainfall intensity, t is the duration, a, b and n are the parameters linked to the local conditions and the return period, if b=0 and n > 0 the equation is known as Montana equation [30], the coefficient γ defines the position of the peak intensity, it varies from 0 to 1.

Considering the equation (6), the cumulated histogram is expressed as

$$H(t) = i_{mm}(t,T).t = a.t^{(b+1)} \quad (9)$$

And the instantaneous intensity as follows

$$I(t) = \frac{\Delta H(t)}{\Delta t} = (\mathrm{b}+1).\mathrm{a}.\mathrm{t}^{b} \quad (10)$$

Considering the vector V corresponding to the rainfall intensities calculated from the IDF for the studied return periods (2, 5, 10, 20, 50, 100 years)

$$v(x_i) = [x_2, x_5, x_{10}, x_{20}, x_{50}, x_{100}] \quad (11)$$

In order to define the rainfall distribution for 24 hours, Montana parameters a and b for each recorded day should be calculated, the amount of precipitation fell in a day i is compared to the rainfall intensities presented in Tables 2. For example y_i is the rainfall of specific day and equal 2 mm, referring to the Table 2, 2 is positioned between the intensity of return period of 50 years and 100 years, to attribute the parameters b to y_i, the value of the x_{50} is grouped with the value of x_{100}, and then subdivided by 2,

- If $y_i \geq \frac{x_{100}+x_{50}}{2}$ the coefficient b of y_i corresponds to the value of the superior born of the considered interval, which is x_{100}.

- If $y_i \leq \frac{x_{100}+x_{50}}{2}$ the coefficient b of y_i corresponds to the value of the inferior born of the considered interval, which is x_{50}.

The parameter is calculated from the Montana formula since, the intensity, the duration, and the parameter b are already defined. The rainfall distribution for 24 hours is then generated using the Chicago formula.The obtaining result is a cumulative rain for 24 hours, the series is redistributed from 1 to 24 hours, a value of 0.5 is attributed to γ, which imply a peak rain in the middle of the day.

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

D. Hydrologic modeling

In the purpose of testing the accuracy of the generated hourly design storm hyetographs, hydrologic modeling under the software HEC HMS was processed.

HEC HMS (Hydrologic engineer Center-Hydrologic Modeling System) is a deterministic semi-distributed model evolved by the United State Army Corps, used for rainfall-runoff modeling in the scale of watersheds, it disposes of a broad range of parameters allowing the transfer of the precipitation to direct runoff and then to flow discharge, the outputs in the flood and dams management, they also could be used for the prediction of the impact of climate change. The rainfall-runoff model has a widespread apply for several regions in the worldwide [31], [32], [33], [34], validated for arid and semi-arid climate context [35], [36], [37], and also for Moroccan climate context [38], [39], [40], [41] and [42]. The model has four major components, the basin model for the description of watersheds (the position of rain and discharge station, the Area, junction, the direction of flow…), the component of the introduction of the physical characteristic of the watershed, the interface for the integration and the management of data, the feature of display of the outputs data [43]. HEC HMS holds nine different methods for losses simulation and seven different transformation method [43], some of them are designed for continuous-time modeling like *Gridded Loss Methods and Soil Moisture Accounting*, the method of *Clark unit hydrograph* and the *Soil Conservation Service Curve Number loss* method successfully simulate the flow discharge in many study cases [33].

Model structure

To simulate the transfer rainfall-runoff under HEC HMS, the SCS-CN method is used for the estimation of the losses, The SCS Unit hydrograph is used as a transfer function, The designed hyetographs derived from Chicago rainfall method was introduced in the meteorological component of the model, it is considered that the whole Ziz catchment receive the same amount of designed precipitation. The routing phase controls the amount of water that goes from the main channel to the outlet, the Lag routing was selected. The choice of this methods is explained by their adequacy to the semi-arid climate context, thing that was proven by the previous study already cited.

Loss Method

SCS curve number grid is used in the presented study to extract the curve number of Ziz watershed. It is calculated from the soil type and land use which both controls the amount of infiltrated water. Soil Conservation Service Curve Number loss method was evolved by the Soil Conservation Service in 1975, in order to estimate runoff from storm rainfall in small to medium size ungauged basin, more detailed description is cited in (McCunen, 2005). The SCS-CN model links the complex land use-soil to the direct runoff by means of the curve number, which represents the runoff according to the antecedent moisture condition (AMC) [44] The AMC represents the percentage of moisture latent in the soil before the begging of the rain event, it has tree classes, the dry, moderate and very wet [45], and symbolized successively as AMC I (CN I), AMC II (CN II), AMC III (CN III), the limit value of the AMC is given in the national Engineering Handbook of Mockus, 1964, and the value of CN II is given in the SCS Manuel, where the value of the two other parameters are estimated from the formula of USDA SCS 1985 [44]:

$$CN_I = 4.2CN_{II} / (10 - 0.058CN_{II})$$
$$CN_{III} = 23CN_{II} / (10 + 0.13CN_{II}) \quad (12)$$

Concerning the soil types, they are classified according to the hydrologic group classification (A, B, C, D) provided by Musgrave in the Handbook of Agriculture.

- ✓ The group A have a high infiltration and low runoff capacity,
- ✓ The group B have a moderate infiltration,
- ✓ The group C have a low infiltration,
- ✓ The group D have a high runoff potential and very low infiltration.

Transfer Method

The Standard Lag time is a mandatory parameter for the chosen method, it measures the difference between the peak rainfall and the peak flow [46], the Soil Conservation Service provide a relatedness between the time of concentration and the lag time by means of the following equation

$$T_{lag} = 0.6T_c$$

$$T_c = \frac{4\sqrt{A} + 1.5L}{0.8\sqrt{H}} \quad (13)$$

Where T_{lag} is the lag time, the T_c is the time of concentration. Tc A is the watershed area in km², L is the length of longest flow path in Km, and H is the difference between the mean basin elevation and the outlet elevation m measured from DEM. Not to mention that there plenty of formula for the estimation of the time of concentration, each one is appropriate to a specific climatic and topographic watersheds characteristic.

Calibration and validation

The calibration aims to estimate the value of non-measurable parameters by reducing the deference between the observed and the simulated hydrographs, two calibration method are disponible, the Manual one which consisted to change the parameters firstly introduced in the model for several attempt and until obtaining the best fit between the observed and the simulated hydrograph, the automatic is based on an optimization algorithm which aims to minimize the objective function and then the difference between the two hydrographs.

The validation evaluates the accuracy of the estimated parameters during the calibration phase, by running the model for a new period of time using the value of the calibrated parameters.

The accuracy of the transfer was assessed by applying the following performance criteria;

- ✓ The coefficient of determination R²: ranges between 0 and 1,
- ✓ Nash-Sutcliffe Efficiency (NSE): ranges from -∞ and 1,
- ✓ RSR: RMSE-observations standard deviation ratio is a statistic error index, a low value of RSR indicates a good simulation, the optimal value is 0,
- ✓ PBIAS: Percent Bias measures the average tendency of the simulated data, a negative value of PBIAS indicate an accurate model when model underestimation is traduced by positive values [47].

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

A detailed description of the cited evaluation criteria is highlighted in Moriasis's performance rating article [48]. In general, model simulation is "satisfactory" if NSE > 0.50, RSR < 0.70, and if PBIAS ±25% [48].

The model set up

The construction steps of the hydrologic model for this study case is summarized as follow

-The treatment of the DEM under HEC Geo HMS, in order to delineate the watershed, define the flow direction and accumulation, and also calculate the physical characteristics of the model, such as area, slope concentration-time, and curve number.

-the generated parameters are introduced in the HEC HMS model, where the hydroclimatic data is added and treated

-The final steps concern the production of the direct runoff and the transfer to the flow discharge by means of the functions the model disposes of.

V. RESULT AND DISCUSSION

The quantile of the probability distribution was obtained using Gumbel law, the reduced variable U allow the estimation of the precipitation for both gage stations Foum Zaabel and Foum Tillicht for each T_j, (j=2, 5, 10, 20, 50, 100) as shown in table I (a and b). The value of the coefficient a and b obtained from the Gumbel distribution were used for the construction of Intensity-Duration-Frequency curves for a duration between 24 and 240 hours. it is observed that as the return period is long the rainfall intensity increase, for example the rainfall intensity for Foum Zaabel station for 24 hours is 1.15 mm/hr for the return period of 2 years, and 2.15 mm/hr for the return period of 100 years which almost the double, inversely the increase of the rainfall duration introduce a reduction in the rainfall intensity, this could be explained by the climatic condition of the region, in an arid climate, the precipitation fall in the wet season of the hydrologic years, during e precipitation event an important amount of rain falls in a short period of time, things that was approved by the study of Huff 1967, who claims that the average rainfall intensity diminished with the duration rise [49]. The intensity obtained by the IFD was used again to generate the distribution during 24 hours by means of Chicago formula (equation 7,8 and 10).The Fig. 3 illustrate the Chicago designed hyetographs related to the IDF curves for the corresponding return time T (2, 5, 10, 20, 50, 100) for the both used station. The resulting hyetographs have a bell shape, intensity increase by the increasing of the return period, for instance, for Foum Zaabel station, the peak rain for T=2 takes a value of 16 mm/hr, and 30 mm/hr for the T=100, concerning Foum Tillicht gage, the intensity rise slightly from the T=2 to T=100, this could be explained by the position of the aforementioned station, the latter is located in shrubland area, thus the scrub, and low woody vegetation moderately diminish the rainfall intensity.

These empirical formulas give just an approximative indication about the shape of the distribution of hourly precipitation during the day, but did not replace the precipitation data registered by gage station, because the equation is not updated to the influence of soil characteristics, land use, the dynamic of the climate and the trend toward the global warming, also the anthropogenic factors.The resulting hyetograph was lately introduced into the distributed hydrologic model HEC HMS, in order to test the accuracy of the generated rain by comparing them with the observed flow recorded by Foum Zaabel and Foum Tillicht.

The hydrologic model was calibrated using the observed flow data at .the stations Tillicht and Foum Zaabel, based on four events relevant of dry and humid period. The general EF average for all rainfall events (Table IV) for Foum Tillicht and Foum Zaabel Station are 0.87 and 0.70, respectively.

Table IV: Modeling Efficiency (EF) for the fourth events

Event	Watershed	Station	EF
08/11/1984 (Dry period)	W780	Tillicht	0.95
	W1090	Foum Zaabel	0.62
14/11/1985(Dry period)	W780	Tillicht	0.97
	W1090	Foum Zaabel	0.75
02/11/1987(Humid period)	W780	Tillicht	0.69
	W1090	Foum Zaabel	0.69
14/11/1989(Humid period)	W780	Tillicht	0.88
	W1090	Foum Zaabel	0.74
Average	W780	Tillicht	0.87
	W1090	**Foum Zaabel**	**0.70**

The minimum EF value is 0.62 for Event 08/11/1984 at Foum Zaabel station and 0.69 for event 02/11/1987 at Foum Tillicht station. The highest EF value is 0.75 for Event 14/11/1985 at Foum Zaabel and 0.97 for event 14/11/1985 at Foum Tillicht station. Thus, a logical accordance between simulations and observed data has been achieved in the hydrologic event modeling. The parameters calibrated in the event model we reused for continuous hydrologic modeling. Due to the lack of continuous observed data, the model was validated using the water supply data to HASSAN ADD-AKHIL dam. Comparisons between the simulated and observed hydrographs at Foum Tillicht and Foum Zaabel stations for the continuous water supply modeling for HASSAN ADD-AKHIL dam is shown in Figs 7. The general average for the continuous hydrologic model value is 0.78(Table V), which is a good fitted correlation between the simulated and observed dam water supply

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

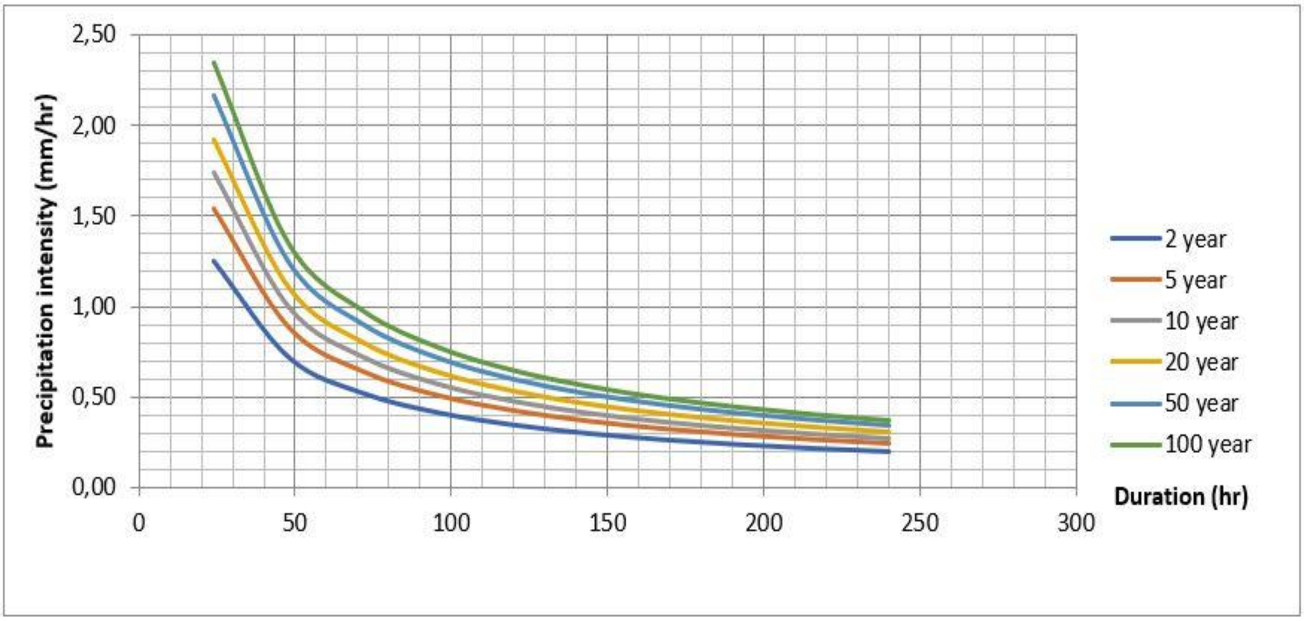

Figure 2: IDF curves for Foum Zaabel station

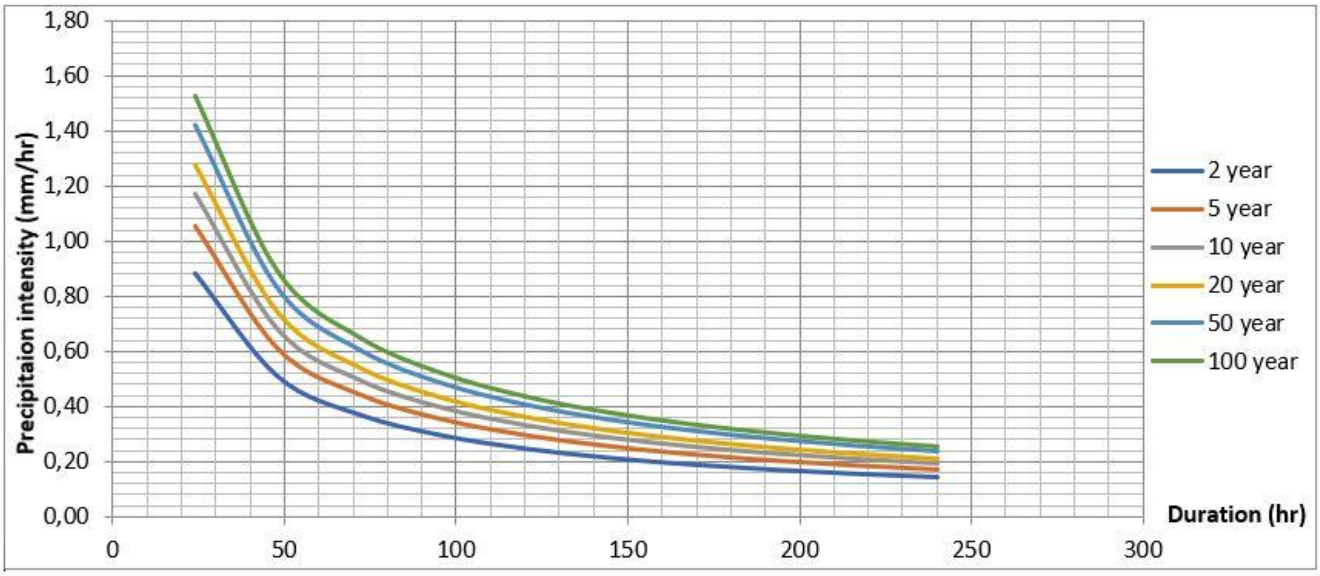

Figure 3: IDF curves for Tillicht station

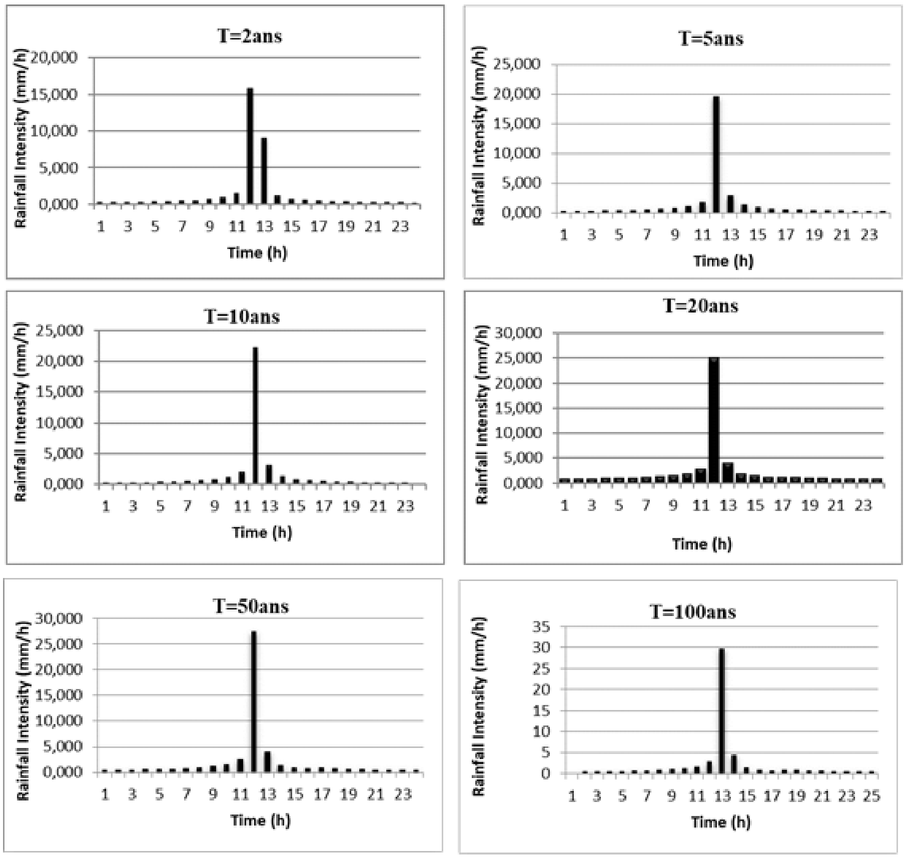

Figure3: The hourly Chicago designed hyetographs for Foum Zaabel station for T_j (j=2, 5, 10, 20, 50, 100)

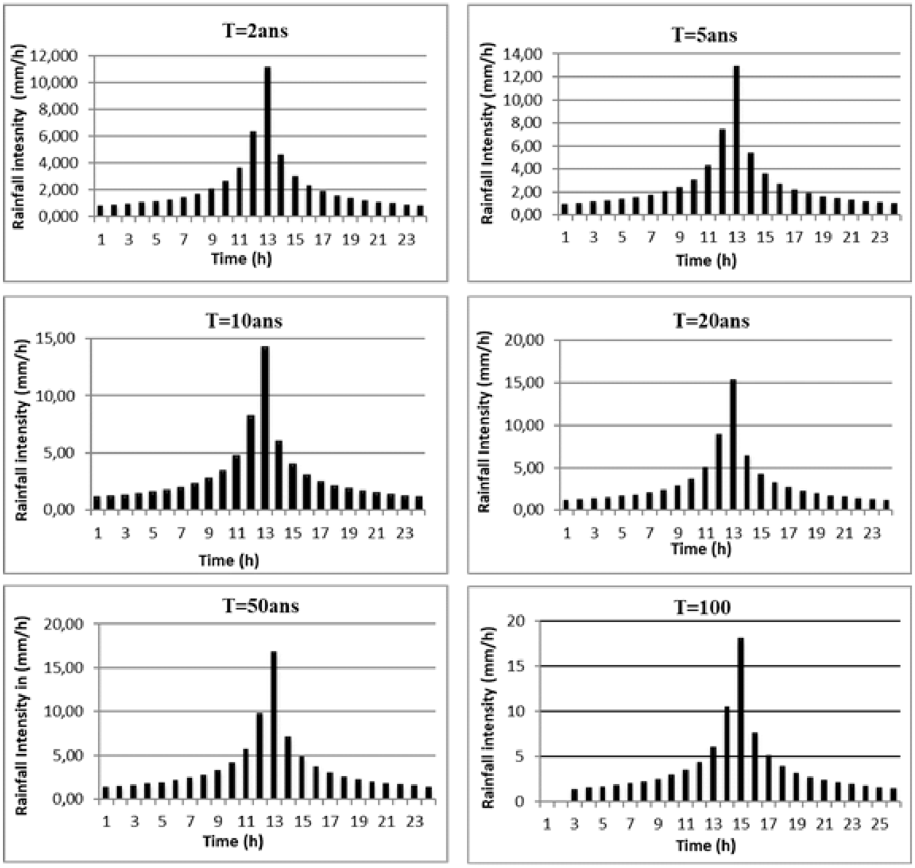

Figure3: The hourly Chicago designed hyetographs for Tillicht station for T_j (j=2, 5, 10, 20, 50, 100)

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

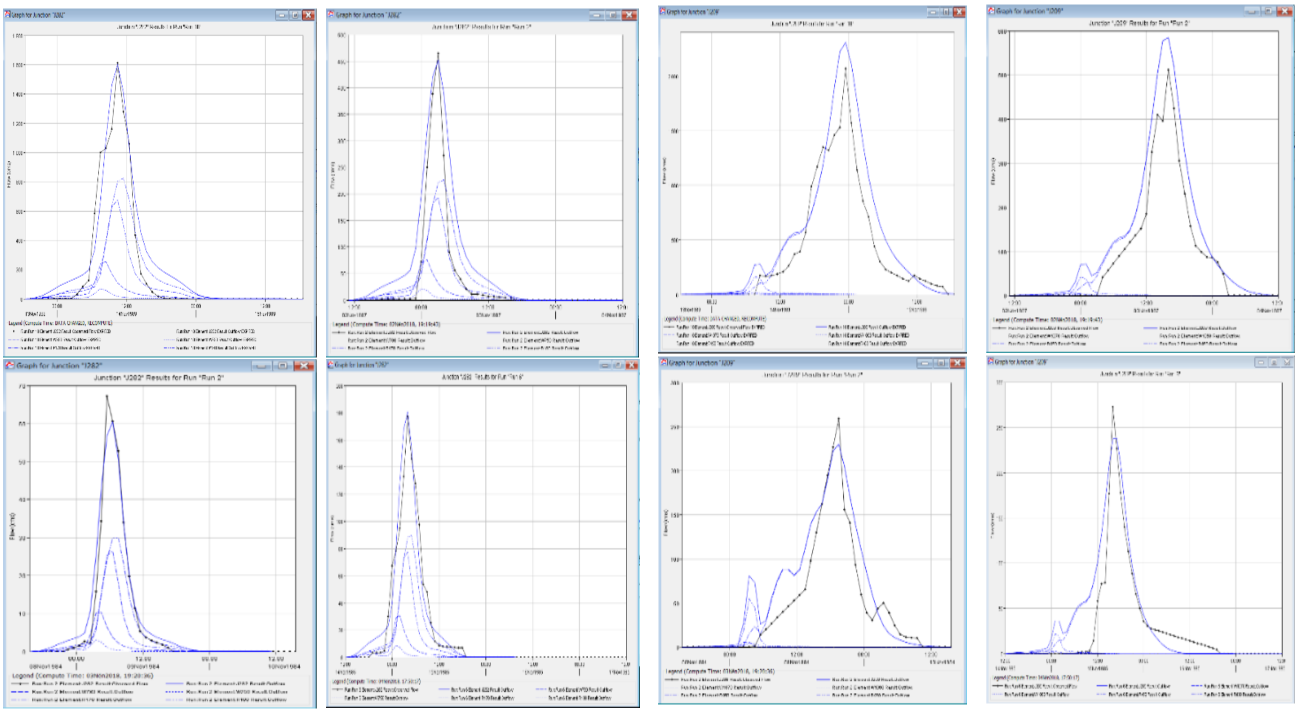

Figure4:The fourth events calibration for FoumZaabel station and FoumZaabel respectively from left to right

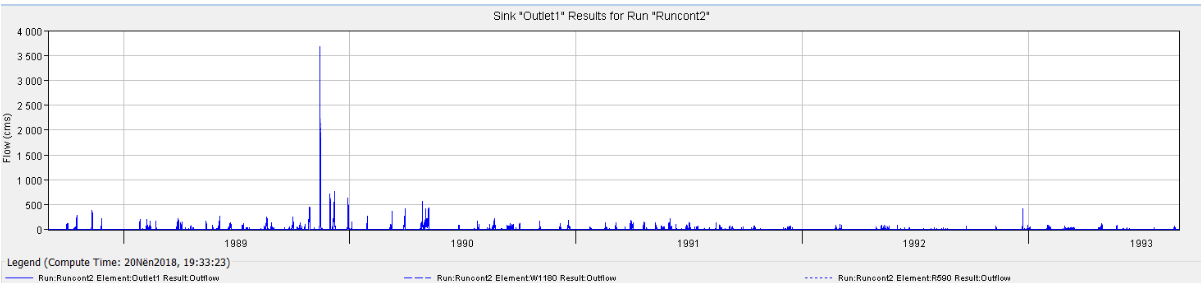

Figure 5: Simulated hydrograph for outlet (HASSAN ADD-AKHIL Dam) (Simulated period: 01/09/88-31/08/1993)

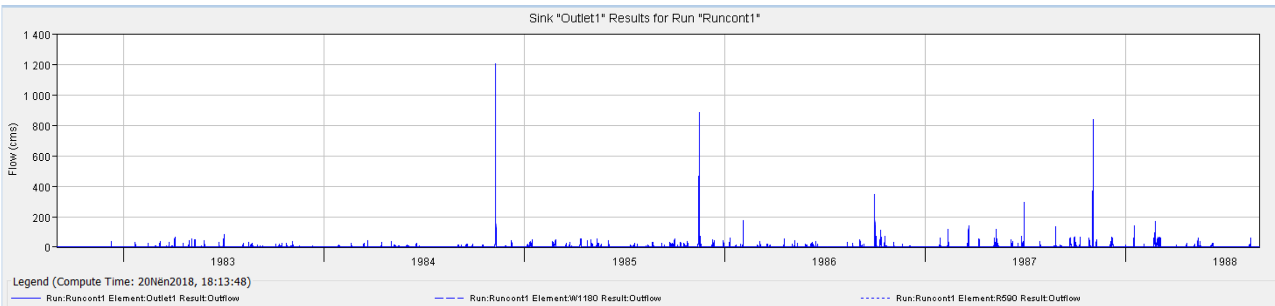

Figure 6: Simulated hydrograph for outlet (HASSAN ADD-AKHIL Dam) (Simulated period: 01/09/82-31/08/1988)

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Table V: Modeling Efficiency (EF) for the period (01/09/1982-31/08/1993)

Period	Watershed	Outlet	EF
01/09/1982-31/08/1982	Upper Ziz	HASSAN ADD-AKHIL Dam	0.78

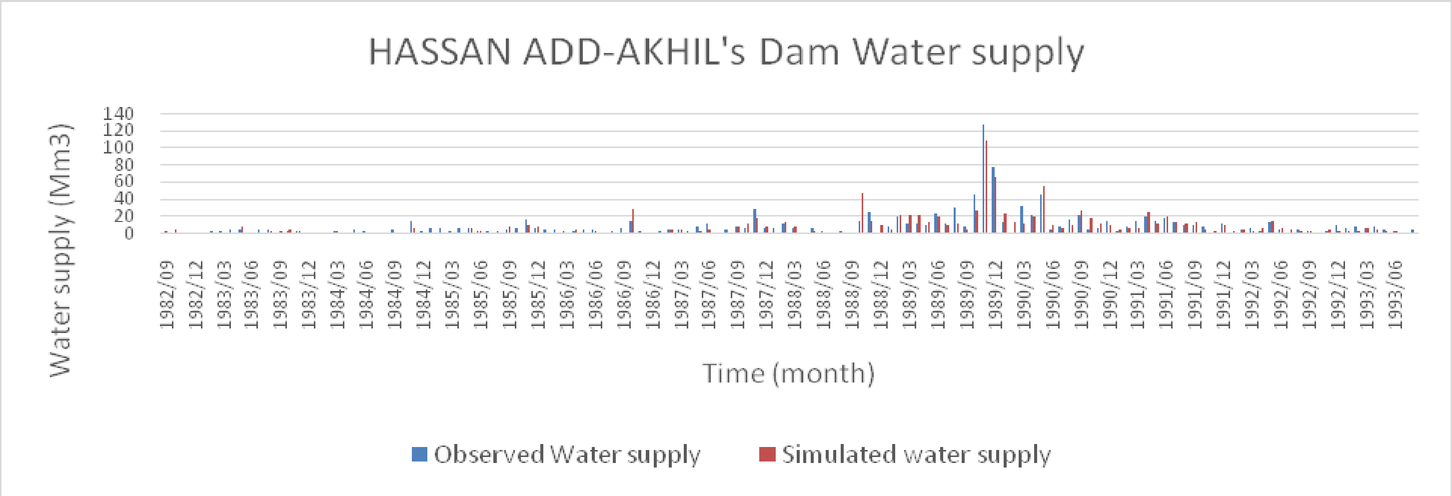

Figure 7: Comparison between Simulated and observed water supply for HASSAN ADD-AKHIL Dam

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

VI. CONCLUSION

The property of the IDF curves was used in this study to generate hourly designed hyetograph, with the purpose data series for 2 gages stations Foum Zaabel and Foum Tillicht.
6 return period of the annual maximum rainfall dataset for different duration (from 24hr to 240hr) were considered, the exceptional case of the Generated Extreme Value distribution Gumbel was used to determine the local quantiles a and b. The Montana IDF curves were established for both stations to determine the rainfall intensity, and then the formula of Chicago proposed by Keifer and Chu was performed on the rainfall intensity obtaining for a duration of 24 hours for the cited return period. Thus, the proposed approach of generating hourly rainfall for ungauged station and its use as an input for hydrological models is an appropriate tools for instantaneous management, especially for arid regions like Ziz Watershed, which require a perpetual management for the water resources to assure a sustainable water supply, the methodology could be transposable for regions with the same climatic context.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support through IRIACC Initiative sponsored by IDRC under the project Number 106372-013.

REFERENCES

1. O. Tanouti, "Squaring the circle : Agricultural intensification vs . water conservation in Morocco," vol. 192, pp. 170–179, 2017.
2. A. Alonso, N. Feltz, F. Gaspart, M. Sbaa, and M. Vanclooster, "Comparative assessment of irrigation systems ' performance : Case study in the Tri ff a agricultural district , NE Morocco," *Agric. Water Manag.*, vol. 212, no. August 2018, pp. 338–348, 2019.
3. V. Te Chow, *Handbook of Applied Hydrology*. New York: USAFrequency, 1964.
4. [4] N. Guru and R. Jha, "Flood Frequency Analysis of Tel Basin of Mahanadi River System, India Using Annual Maximum and POT Flood Data," *Aquatic Procedia*, vol. 4. pp. 427–434, 2015.
5. B. Bobée, G. Cavadias, F. Ashkar, J. Bernier, and P. Rasmussen, "Towards a systematic approach to comparing distributions used in flood frequency analysis," *J. Hydrol.*, vol. 142, no. 1–4, pp. 121–136, 1993.
6. H. A. Ewea, A. M. Elfeki, and N. S. Al-Amri, "Development of intensity–duration–frequency curves for the Kingdom of Saudi Arabia," *Geomatics, Nat. Hazards Risk*, vol. 8, no. 2, pp. 570–584, 2017.
7. F. A. K. Farquharson, J. R. Meigh, and J. V. Sutcliffe, "Regional flood frequency analysis in arid and semi-arid areas," *J. Hydrol.*, vol. 138, no. 3–4, pp. 487–501, 1992.
8. H. Bendjoudi, P. Hubert, and D. Schertzer, "Interphation multifractale des prkipitations Multifractal curves," *Sci. York*, pp. 323–326, 1997.
9. A. P. García-Marín, R. Morbidelli, C. Saltalippi, M. Cifrodelli, J. Estévez, and A. Flammini, "On the choice of the optimal frequency analysis of annual extreme rainfall by multifractal approach," *Journal of Hydrology*, vol. 575. pp. 1267–1279, 2019.
10. A. Hajani, Evan Rahman, "Design rainfall estimation : comparison between GEV and LP3 distributions and at-site and regional estimates," *J. Artic.*, vol. 93, no. 1, pp. 67–88, 2018.
11. B. Mohymont and G. R. Demarée, "Courbes intensité-durée-fréquence des précipitations à Yangambi, Congo, au moyen de différents modèles de type Montana," *Hydrol. Sci. J.*, vol. 51, no. 2, pp. 239–253, 2006.
12. A. Kingumbi and A. Mailhot, "Courbes Intensité-Durée-Fréquence (IDF): Comparaison des estimateurs des durées partielles et des maximums annuels," *Hydrol. Sci. J.*, vol. 55, no. 2, pp. 162–176, 2010.
13. C. O. Cardoso, I. Bertol, O. J. Soccol, and C. A. De Paiva, "Generation of Intensity Duration Frequency Curves and Intensity Temporal Variability Pattern of Intense Rainfall for Lages / SC," pp. 1–10, 2009.
14. M. Rasel and S. M. Hossain, "Development of Rainfall Intensity Duration Frequency (R-IDF) Equations and Curves for Seven Divisions in Bangladesh," vol. 6, no. 5, pp. 96–101, 2015.
15. S. City, "Developing Rainfall Intensity-Duration-Frequency Relationship for Central Zone of International Journal of Advance Engineering and Research Developing Rainfall Intensity-Duration-Frequency Relationship for Central Zone of Surat City , Gujarat , India," no. April, 2017.
16. F. Cernesson, J. Lavabre, and J. Masson, "Stochastic model for generating hourly hyetographs," vol. 42, pp. 149–161, 1996.
17. C. I. Pilgrim DH, *Flood runoff. In Handbook of Hydrology*, vol. 9. New York (NY): McGraw-Hill, 1993.
18. L. Alfieri, F. Laio, and P. Claps, "A simulation experiment for optimal design hyetograph," no. March, 2008.
19. and V. T. C. Yen, B. C., "Design hyetographs for small drainage structures," *ASCE J. Hydraul. Div.*, vol. 106 (HY6), pp. 1055–1076, 1980.
20. S. V, "Entwicklung eines Berechnungsregens f¨ur die Bemessung von Kanalnetzen," *GWF-Wasser/Abwasser 114*, vol. 114, pp. 435–440, 1973.
21. and P. V. Veneziano, D., "Best linear unbiased design hyetograph," *Water Resour. Res.*, vol. 35 (9), pp. 2725–2738, 1999.
22. C. H. Keifer CJ, "Synthetic storm pattern for drainage design," *ASCE J. Hydraul. Div. 83(HY4)*, pp. 1–25, 1957.
23. S. Grimaldi and F. Serinaldi, "Best linear unbiased design hyetograph," *Hydrol. Sci. J.*, vol. 51, no. 2, pp. 223–238, 2006.
24. "Catchment scale controls the temporal connection of transpiration and diel fluctuations in streamflow," *Hydrol. Process.*, vol. 26, no. November 2009, pp. 1–16, 2012.
25. T. Bahaj, I. Kacimi, M. Hilali, N. Kassou, and A. Mahboub, "Preliminary study of the groundwater geochemistry in the sub-desert area in Morocco : case of the Ziz-Ghris basins," *Procedia Earth Planet. Sci.*, vol. 7, pp. 44–48, 2013.
26. D. Madsen, H., Rasmussen, P. F. & Rosbjerg, "Comparison of annual maximum series and partial duration series method for modelling extreme hydrologic events: 1. at site modelling," *Water Resour. Res.*, vol. 33(4), pp. 747–757, 1997.
27. Chow VT, *Applied hydrology*. New York (NY): McGraw-Hill, 1988.
28. C. Chen, "Rainfall intensity-duration-frequency formulas," *J. Hydraul. Eng*, vol. 109 (12), pp. 1603–1621, 1983.
29. F. . Bell, "Generalized relationships," *J. Hydraul. Eng*, vol. 95 (HYI), pp. 311–327, 1969.
30. P. Alegre, "Cumulative equations for continuous time Chicago hyetograph method," pp. 646–651, 2016.
31. D. Abdessamed and A. Bouanani, "Hydrological modeling in semi-arid region using HEC-HMS model. case study in Ain Sefra watershed, Ksour Mountains (SW-Algeria)," no. October, 2017.
32. K. Kaffas, "Application of a continuous rainfall-runoff model to the basin of kosynthos river using the hydrologic software HEC-HMS APPLICATION OF A CONTINUOUS RAINFALL-RUNOFF MODEL TO THE BASIN OF KOSYNTHOS RIVER USING THE HYDROLOGIC SOFTWARE HEC-HMS," no. April, 2015.
33. D. Halwatura and M. M. M. Najim, "Environmental Modelling & Software Application of the HEC-HMS model for runoff simulation in a tropical catchment," *Environ. Model. Softw.*, vol. 46, pp. 155–162, 2013.
34. M. M. G. T. De Silva, S. B. Weerakoon, and S. Herath, "Modeling of Event and Continuous Flow Hydrographs with HEC–HMS: Case Study in the Kelani River Basin, Sri Lanka," *J. Hydrol. Eng.*, vol. 19, no. 4, pp. 800–806, 2014.
35. W. Gumindoga, D. T. Rwasoka, I. Nhapi, and T. Dube, "Ungauged runoff simulation in Upper Manyame Catchment, Zimbabwe: Applications of the HEC-HMS model," *Phys. Chem. Earth*, 2016.
36. M. Wang, L. Zhang, and T. D. Baddoo, "Hydrological Modeling in A Semi-Arid Region Using HEC-HMS," no. September, 2016.
37. M. Hydrology, "Modelling Hydrology and Sediment Transport in a Semi-Arid and Anthropized Catchment Using the SWAT Model : The Case of the Tafna River."
38. R. Bouabid and C. Elalaoui, "Impact of climate change on water resources in Morocco: The case of Sebou Basin," *Séminaires Méditerranéens*, vol. 95, pp. 57–62, 2010.
39. "Hydrological simulation (Rainfall-Runoff) of Kalaya watershed (Tangier, Morocco) using Geo-spatial tools," *J. Water Sci. Environ. Technol.*, vol. 1, no. 1, pp. 10–14, 2016.
40. "Production of a Curve Number map for Hydrological simulation - Case study: Kalaya Watershed located in Northern Morocco," *Int. J. Innov. Appl. Stud.*, vol. 9, no. 4, pp. 1691–1699, 2014.

41. Y. Tramblay *et al.*, "Estimation of antecedent wetness conditions for flood modelling in northern Morocco," *Hydrol. Earth Syst. Sci.*, vol. 16, no. 11, pp. 4375–4386, 2012.
42. N. El Mahmouhi, M. El Wartiti, S. A. Wissem, S. Kemmou, and S. E. L. Bahi, "Utilisation des systèmes d ' information géographiques et des modèles hydrologiques pour l ' extraction des caractéristiques physiques du bassin versant d ' Assaka (Guelmim , sud du Maroc) [The use of geographic information system for the extraction of," vol. 16, no. 2, pp. 370–377, 2016.
43. Engineers U S Army Corps, "Hydrologic modeling system (HEC-HMS) application guide: version 4.0. 0," *Inst. Water Resour. Davis*, no. December, 2013.
44. X. Bo, W. Qing-hai, F. A. N. Jun, H. A. N. Feng-peng, and D. A. I. Quan-hou, "Application of the SCS-CN Model to Runoff Estimation in a Small Watershed with High Spatial Heterogeneity ∗ 1," *Pedosph. An Int. J.*, vol. 21, no. 6, pp. 738–749, 2011.
45. H. Microwatershed, "APPLICATION OF SCS-CN METHOD FOR ESTIMATION OF RUNOFF IN A," no. July, 2016.
46. USGS, "Estimating Basin Lagtime and Hydrograph-Timing Indexes Used to Characterize Stormflows for Runoff-Quality Analysis.Scientific Investigations Report," 2012.
47. P. O. Gupta, H. V., Sorooshian, S., & Yapo, "Status of automatic calibration for hydrologic models: Comparison with multilevel expert calibration," *J. Hydrol. Eng.*, no. 4(2), pp. 135–143, 1999.
48. & V. Moriasi, Arnold, Van Liew, Bingner, Harmel, "Model evaluation guidelines for systematic quantification of accuracy in watershed simulation," *Acad. Press*, 2007.
49. H. FA, "Time distribution of rainfall in heavy storms," *Water Res Res*, vol. 3(4), pp. 1007–1019, 1967.

AUTHORS PROFILE

Mr Ismail Elhassnaoui is Ph.D student at the Civil Engineering Department at Ecole Mohammadia d'Ingénieurs (EMI). Mohamed V University. He is rural engineer. His research interests: Hydrologie, water resources management, disaster management…

Ms Zineb Mounen is Phd student at the Georesources and environement department at university of Sidi Mohamed Ben Abdelah (Fes). She is Master graduate in Georesources and environement. Her research interest : Hydrologie, water resources management, disaster management…

Dr. Ahmed Bouziane, is graduated from Ecole Mohammadia d'Ingénieurs with a degree of Civil Engineer, Hydraulics. His works on hydrologic modeling, erosion and dam's siltation, climate change impact and adaptation, rainwater harvesting, droughts, inundation.

Dr. Driss Ouazar is graduated from Ecole Mohammadia d'Ingénieurs with a degree of Civil Engineer, Hydraulics in 1977, and a Ph.D in Hydromechanics from Luick University in Belgium in 1983. His past research encompasses development and applications of computational and experimental techniques for engineering and science especially Finite Element, Finite Volume and Boundary Element and meshes less Methods for water resources, environment and hydraulics.

Dr. Moulay Driss Hasnaoui with an experience of 30 years, he was graduated MOSc, then Engineer and Ph.D. Started Working for a consultants company in IWRM, before joining, few years after, what is today the Ministry Delegate for Water where he continue develop water resources and rural drinking water supply. His works are among others on hydrologic modeling, erosion and dam's siltation, climate change impact and adaptation, rainwater harvesting, droughts, inundations….

Retrieval Number: J12140881019/19©BEIESP
DOI: 10.35940/ijitee.J1214.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)