International Journal of Latest Research in Humanities and Social Science (IJLRHSS)
Volume 06 - Issue 05, 2023
www.ijlrhss.com || PP. 142-151

Assessment of anthropogenic activities impact on the water balance by applying hydrological model Orchy II within the Tassaout basin (upstream of Moulay Youssef dam) (1986-2010) (Morocco)

Chakir Mohamed[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: The Tassaout basin is located in the Central High Atlas of Morocco. It belongs to a semi-arid climatic context, is characterized by a low rainfall. The region is suffered from an increasing demand of water despite its scarcity and its unequal distribution due to the climate change effect observed at global scale. The purpose of this contribution is to release a monthly quantification of the hydrological balance basing on the hydrometric gauging stations of Tamsemat and AitTamlil. This latter considers the anthropogenic factors in order to quantify the irrigation water abstraction by adopting the Hydrological model Orchy II which considers the most important variables that could influence the hydrological functioning of the basin, namely precipitation, evapotranspiration, flow and above all anthropogenic impact. The model has proven its effectiveness in term of the analysis of the elements of the hydrological balance sheet and in showing the anthropic impact on the hydrological functioning of the basin, where water samplings represent 14% of the annual module.

Keywords: Tassaout basin (upstream of the dam Moulay Youssef), Hydrological model, Hydrological balance, Anthropogenic impact.

1. Introduction

In the context of the growing needs for water resources especially in semi-arid climate regions, and taking into account the important development that Morocco has experienced in the field of water resources management, this article aims to contribute effectively to carry out a hydrological balance of the study area, analysing the relation between the rainfall and the flow, and try to consider all the natural and human variables. The studied basin considered as an edifying example for the study of hydrological functioning, from a hydro-climatic study of the basin, and from the development of a hydrological balance based on the quantification of three key climatic parameters; precipitation, flow and evapotranspiration.

The study of flow is mainly associated with the question of climatic and anthropogenic factors of the basin, which generate complex changes in time and space.

This work is a contribution to the development of a hydrological balance of the basin, based on the quantification of water resources, using the Orchy II hydrological model, which presents a complex system making it possible to approach the functioning of the water cycle in the basin, based on climatic variables (P, Q and ETP) (El Ghachi, 2014), and to take into account the anthropogenic impact on water resources, and to identify its operation in the basin.

The Orchy II model, like all other models, allows an interpretation of reality within a conceptual framework based on simplifications and approximations of reality. Besides, the link between the model and the real world is based on the data that characterize the latter (Perrin, 2000). Our choice fell on this conceptual model with reservoirs, because it answers our concerns of representation of the hydrological cycle because it integrates the complex factors while trying to describe the physical concept of the behaviour of the system by a simpler representation (Makhlouf, 1994).

2. Presentation of the study area

In the context of the growing needs for water resources especially in semi-arid climate regions, and taking into account the important development that Morocco has experienced in the field of water resources management, this article aims to contribute effectively to carry out a hydrological balance of the study area, analysing the relation between the rainfall and the flow, and try to consider all the natural and human variables. The studied basin considered as an edifying example for the study of hydrological functioning, from a hydro-climatic study of the basin, and from the development of a hydrological balance based on the quantification of three key climatic parameters; precipitation, flow and evapotranspiration.

The study of flow is mainly associated with the question of climatic and anthropogenic factors of the basin, which generate complex changes in time and space.

This work is a contribution to the development of a hydrological balance of the basin, based on the quantification of water resources, using the Orchy II hydrological model, which presents a complex system making it possible to approach the functioning of the water cycle in the basin, based on climatic variables (P, Q and ETP) (El Ghachi, 2014), and to take into account the anthropogenic impact on water resources, and to identify its operation in the basin.

The Orchy II model, like all other models, allows an interpretation of reality within a conceptual framework based on simplifications and approximations of reality. Besides, the link between the model and the real world is based on the data that characterize the latter (Perrin, 2000). Our choice fell on this conceptual model with reservoirs, because it answers our concerns of representation of the hydrological cycle because it integrates the complex factors while trying to describe the physical concept of the behaviour of the system by a simpler representation (Makhlouf, 1994).

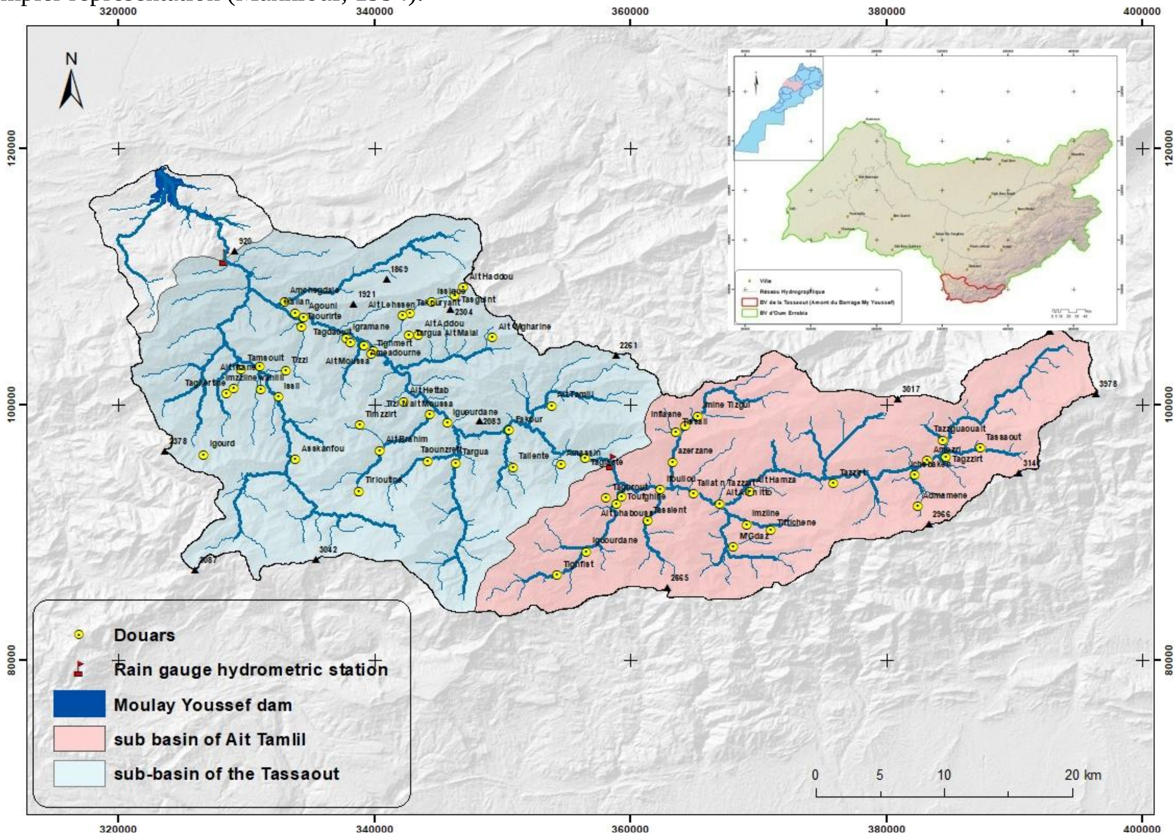

Figure 1 Localisation of the Tassaout basin within Oum Err Bia Basin (upstream of the Moulay Youssef Dam).

The climate of the basin is Mediterranean with oceanic and continental influences. with very high summer maximum temperatures and lower minimum temperatures than those recorded on the coast. The influence of altitude becomes predominant, and rainfall increases again from the down to the peaks of the Atlas (ABHOER, 1972).

However, the difficulties encountered for a better management of water resources are crucial, given the climatic changes that the world has experienced in general, and the arid and semi-arid zones, since the water balance can be influenced by natural factors. and humans.

The Tassaout basin (upstream of the Moulay Youssef dam) has undergone significant hydro-agricultural developments, giving rise to a massive expansion of irrigated agricultural activities. Human intervention had a remarkable impact on the hydrological functioning of the watercourse, and consequently on the filling of the Moulay Youssef Dam.

Thus, human activities are major global issues:

- Human action (development of watercourses, abstraction, etc.) modifies the parameters of this cycle and induces quantitative changes in the flow;
- These quantitative degradations have an impact on water resources and their availability.

Faced with the problem of water scarcity, particularly due to climate change and increased demand for water, efficient and rational management of the resources of this vital material remains the only way to escape this critical situation.

3. Methodology and data

3.1 Data analysis

To study the impact of anthropogenic factors and climate change on the water balance, it was necessary to highlight and better understand the basin, through a study of hydrological functioning, by analysing the human-water resources relationships at basin (Mouhdi, 1993). In this context, we have focused on the study of the water resources available in the Tassaout basin, using a statistical and analytical methodology of the data available (Precipitation, flow, evapotranspiration, etc.). In a second step this work consists in estimating the abstractions in various uses, in order to deduce the impact of the current management of water resources in the basin on the hydrological balance and to highlight the water deficits or surpluses. However, an analyse of the water balance by adopting a hydrological model will be realized. The study area is equipped with two pluviometric stations and two hydrometric stations, equipped with a limnimetric scale and a water gauge. AitTamlil upstream of the basin and Tamsemat downstream of the basin, which are installed on the Tassaout river, and which are managed by the Oum Er Rbia Hydraulic Basin Agency. A single thermal station located outside the basin (AitSegmine).

3.2 Representation and application of the Orchy II Model

Several models have been tried to model the hydrological balance (general model of the water balance, GR2M rural engineering model), but in this contribution we have chosen the OrchyII model, it is a simple overall conceptual model for the representation of the functioning of the water cycle. water in a basin, from climatic variables (P, Q and ETP). The model uses three reservoirs and 4 optimization parameters (Gille and Lang, 2004). The model used is that of Thorntwaite added to a finish of (Gille, 1985). Thanks to computers, it was possible to establish the various terms of the water balance in a program carried out in Excel. It presents a complex system which makes it possible to approximate the functioning of the water cycle in the basin, from climatic variables (P, Q and ETP). The model also characterized by the possibility of integrating the anthropogenic influence on the flow.

The structure of this model can be broken down into two important elements which are the inputs and outputs of the model (Fig. 2). The model relates precipitation, potential evaporation (ETP), variations in soil reserve (DR) and the amount of water withdrawn.

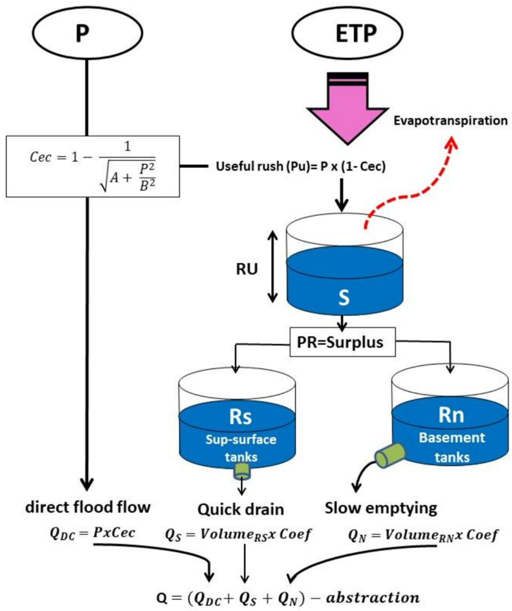

Figure 2 Architecture of the Orchy II hydrological model in the Tassaout basin (upstream of the Moulay Youssef dam).

From this diagram, an attempt to explain the most important elements in the model will follow. The first stage of the model performs the production function, that is, the conversion of raw rain into net rain. This function therefore seeks to represent the interaction of precipitation with the soil to determine the proportion of rainfall that flows directly from that which infiltrate into the soil (Qadem, 2015). The production function is ensured by an RFF (Rapid Flood Flow) equation resulting from the formulation of Turc. $Q_c = 1 - \frac{1}{\sqrt{A+\frac{P^2}{B^2}}}$

The values of A and B can be adjusted according to the seasons.

The transfer function, making it possible to generate the flood hydrograph from the net precipitation, is provided by 3 cascade reservoirs, the first of which is used to represent the water balance. This is a "soil tank" characterized by its maximum useful reserve (Ru). The variation of the useful reserve is ensured by an agro-climatic approach of the water balance. This approach can be broken down into three phases (Riou, 1975):

- Phase 1: P <ETP then ETR = P - RFF, all the rain is used by evapotranspiration, the rain is the limiting factor.
- Phase 2: P> ETP then ETRmax = ETP, it is the energy provided by the climate that is the limiting factor.
- Phase 3: P <ETP then ETR obeys the law which reflects the increasing effort to extract water from the soil reserve as it dries up. ETR / ETP = exp [(- 1 / RU) ∫ETP.dt] with Ru being the water reserve of the soil. In this case, it is the water reserve in the soil that is the limiting factor.

3.3 The inputs of the Orchy II model

The data necessary for the operation of the model are the monthly precipitation received by the basin, the monthly flow at the outlet as well as the average monthly evapotranspiration. The reconstitution of this database required prior data processing (Alley, 1985). The study period used is 1986-2010.

a- Precipitation

The rainfall data necessary for the operation of the model are the monthly rainfall contributions for the entire basin, from 1986 to 2010. The missing data in the series were completed by the correlation method (Dubreuil, 1974), which consists of verifying classical precipitation chronicles by correlations item by item and month by month. The precipitation inputs were estimated from the rainfall data recorded at the two climatic stations distributed over the basin by the rainfall gradient method (Boudhar, 2009). The Tassaout basin (upstream of the Moulay Youssef dam) was subdivided into two sub-basins, the AitTamlil sub-basin and the Tamsemat sub-basin, each of which has a specific area and its own natural and anthropogenic characteristics.

b- Evapotranspiration

ETP represents the total amount of water evaporated. This term includes physical evapotranspiration (from the soil, the water surface, etc.) and plant transpiration. Evapotranspiration is an essential factor in water balance models of basins. In these models, a mathematical formulation is generally used to estimate this factor, knowing the evolution of certain parameters characterizing the climate of the basin.

The formula which has been the subject of this study is that of (Thornthwaite and Mather. 1957), based on temperature data from the Ait Segmine station outside the basin to the north.

$$ETP=16(10\ T/I)^a.K$$

ETP: monthly evaporation in mm;
t : monthly average temperatures;
I : annual thermal index which is the sum of the twelve monthly values of i;
K : Correction coefficient which is a function of the latitude of the place;

So
a=0.016 * I + 0.5;
$I = \sum_{m=1}^{12} i(m)$ With $i=(0.2T\ °c)^{1.514}$

Evapotranspiration data were also spatialized based on the thermal gradient equation (chronic from 1986 to 2013).

c- Flow data

The flow data available to us are those measured at the outlet of the basin at the level of the Tamsemat hydrometric station, and of the AitTamlil sub-basin at the level of the AitTamlil hydrometric station over the common period 1986-2010.

d- Water sampling

The basin is characterized by a very important human dynamic, and by traditional agricultural activities. In this study, we relied on the study of irrigated agricultural activities, which require large amounts of water. We therefore worked on a global assessment of water resources, which are taken directly from watercourses or sources and emergences, using the Seguias system, from an inventory and cartographic work, and based on data managed by the Provincial Directorate of Agriculture of Azilal (DPAA), followed by a field study to estimate the flows of the Seguiasin order to determine the quantity of water withdrawn.

Figure 3 Field work measurement and validation of Orchy II model (upstream of the My Youssef dam)

The length of the Seguias, through which water is distributed over irrigated agricultural areas over a total area of 4649 hectares, is 186 km (DPAA, 2014). Irrigation water towers range from 7 to 15 days and vary from season to season and year to year.

The main objective of this inventory is to estimate the quantity of water withdrawn, to understand the anthropogenic impact on hydrological functioning. The following table summarizes the estimate of the annual volume of water withdrawn.

Table 1. Estimated volume of water withdrawn at annual scale.

Type of seguia	Debit (l/s)	Sample volume (m^3/year)	Sum (m^3/year)
Perennial Seguia	1070	33743520	52371360
Temporary Seguia	880	18627840	

The flow rate of the water sampling ranges between 30 and 180 l / s-1, this volume of water must be considered in the hydrological balance of the basin.

3.4 - Orchy II model calibration parameters

To run the hydrological model, it was necessary to calibrate other parameters including the flood runoff coefficient, the dry-off coefficient, and the soil reservoir.

- The monthly rapid flood flow coefficient estimated according to precipitation.
- The soil reservoir, around 50 mm, which is the value generally retained for the Tassaout basin.
- The proportion of the flow deferred to the following month for the rapid emptying tank (representing subsurface flows, perched water tables, soil drainage), with, where applicable, a monthly rapid emptying coefficient.
- The monthly drying coefficient of the slow draining tank (representing the water tables).

However, this calibration remains a relatively delicate operation insofar as, on the one hand, these parameters are not calculated and, on the other hand, it was necessary to act jointly on the values of the monthly flow coefficients and the monthly coefficient drying up.

4. Results

The results of hydrological modeling can be represented using the OrchyII model at the level of two-time steps. at the annual scale for the water balance and at the monthly scale for the flow regime. The setting of the parameters is linked, on the one hand, by the characteristics of the flow regime, which present a level of analysis of hydrological functioning, and on the other hand with the physiographic characteristics of the basin (El Ghachi, 2007).

4.1 The hydrological functioning at annual scale (1986-2010)

The Tassaout basin is treated as a system made up of several small catchments. This is the reason why we find the results with two hydrological balances which correspond to two sub-catchments, as well as the third hydrological balance which corresponds to the overall basin of the Tassaout. The table below explains the approach adopted, as well as the results obtained on an annual basis:

Table 2 the Hydrological balance results of the study area at annual scale (Orchy2) (1986-2010).

Value (mm)	Tamsemat sub-basin	AitTamlil sub-basin	Basin of Tassaout (upstream of the My Youssef dam)
Precipitation (P)	631	696	663
Evapotranspiration Potential (ETP)	908	786	848
Real Evapotranspiration (REE)	374	356	369
Flood flow (QC)	136	92	209
Groundwater flow (QN)	241	163	119
Water transfer inside or outside the basin (Tr)	+120	-85	+34
Water withdrawn (Pr)	-48	-33	-40
Simulated flow	329	222	288
Measured flow	329	222	288

The results of the annual water balance for the Tassaout basin can be schematized as follows (Fig. 4):

Due to the high altitudes characterizing the Ait-Tamlil catchment, the latter experiences significant rainfall, but it only has a very low runoff coefficient (32%) compared to the Tamsemat catchment, this is due to with the high permeability characterizing the basin (Mouhdi. 1993), while the transfer of water to the neighboring basins reaches 85 mm. This basin is also characterized by a significant water table emptying which reaches 163 mm, which explains the constant flow of the main watercourse throughout the year. The water samplings represent 15% of the total flow of the catchment, which cannot be neglected in the preparation of the hydrological balance.

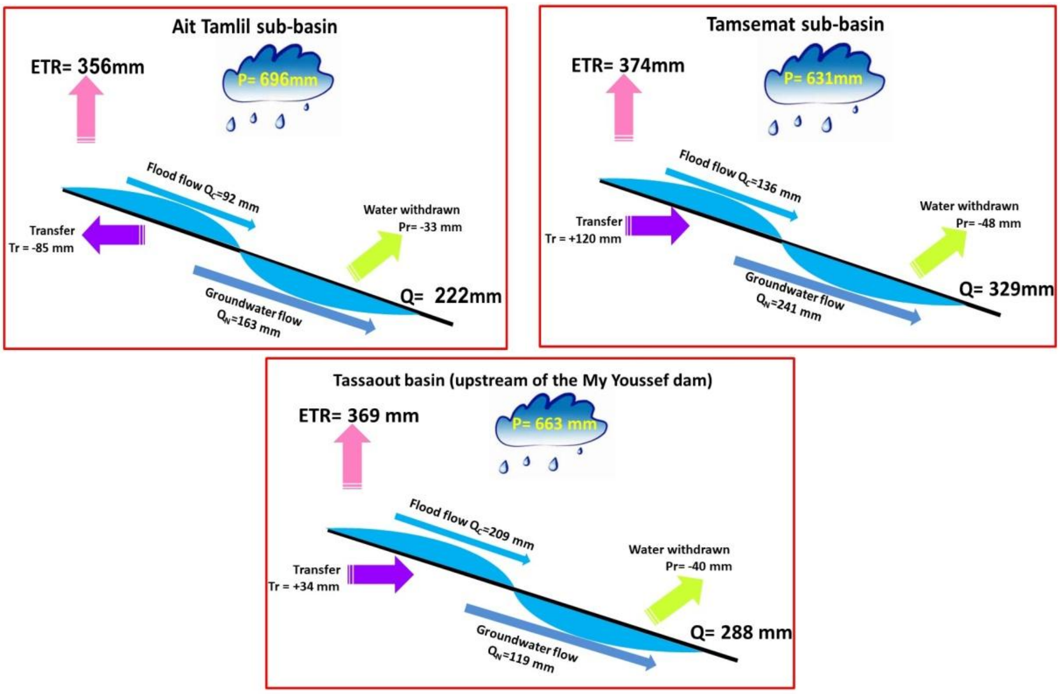

Figure 4 Hydrological water balance of the study area (1986-2010)

The Tamsemat catchment has a very high runoff coefficient, which represents 52% of precipitation during the statistical series (1986-2010), due to the hydrogeological transfer of a large quantity of water resources transmitted by neighboring basins. The water samplings represent 14% of the total flow of the basin.

While the entire basin is characterized by additive water resources transmitted by neighboring basins having 34mm in volume. The quantity of water samplings is 40mm, which represents 14% of the total flow of the Tassaout basin (upstream of the Moulay Youssef dam). The annual hydrological balance of the basin can be summarized as follows:

(P)663 mm=(Q)288mm+(ETR)369mm+(Pr)40mm-(TR)34mm

Generally, the annual water balance gave us an idea of the hydrological functioning of the Tassaout basin (upstream of the Moulay Youssef dam), and the two catchments. Thus, he showed the importance of flows in the basin, but it was necessary to carry out a monthly assessment to fully understand the mechanisms and parameters that influence the surface flow.

4-2- Hydrological response at monthly scale (1986-2010)

The monthly study allows us to determine the different variables of the hydrological balance, and to approach the different forms of flow, from the analysis of precipitation, the flow of water and the flood coefficient (El Ghachi 2007).

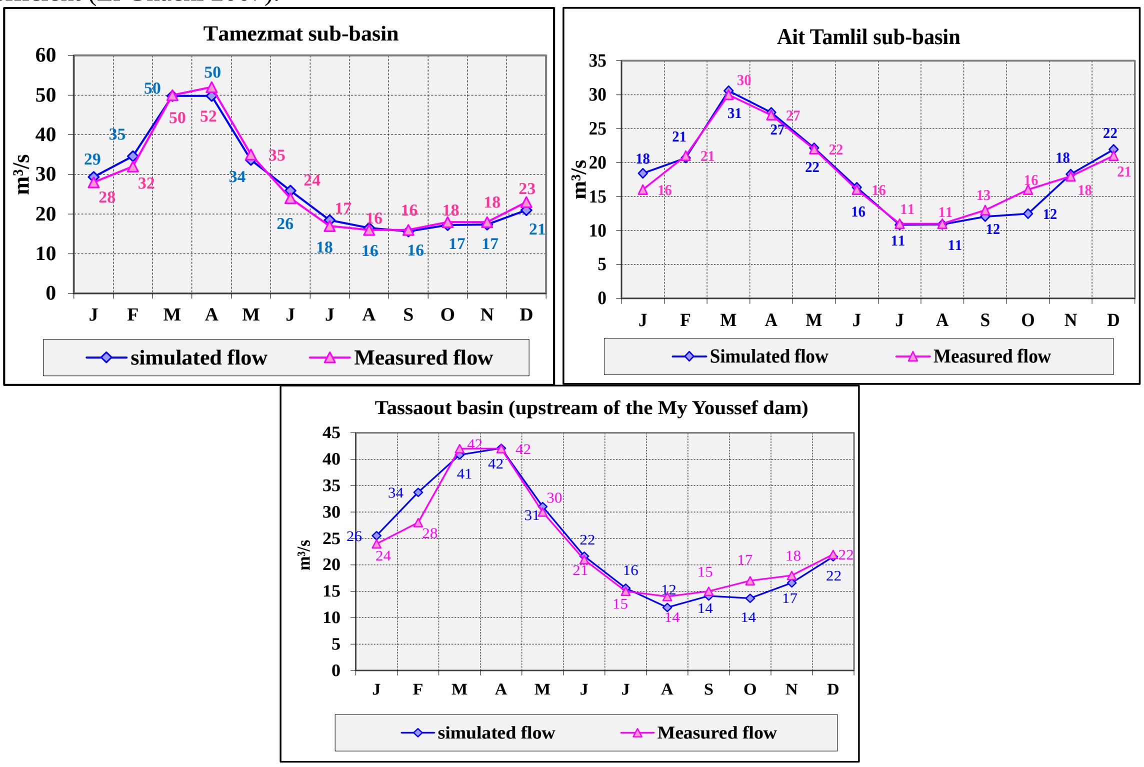

Figure. 5. Comparison of measured and simulated flows on a monthly scale (1986-2010)

The results of the hydrological modelling of the study basin were satisfactory at the monthly level, according to the linear correlation values (Dubreuil 1974) between the measured discharge and the simulated discharge which reached 0,96 for the Tassaout basin (upstream of the Moulay Youssef dam), and 0,95 for the Ait-Tamlil catchment and 0,98 for the Tamsemat catchment. the hydrological year in the study basins can be separated into two different periods:

- Period of high water (Quick-flow) characterized by a significant flow during the year. The months January February are not strongly affected by interesting rainfall during these months, yet the flow begins to rise until reaching its maximum value during the months of March and April for the three basins. This explains the contribution of snowmelt water to the flows of the main Atlas wadis (Boudhar, 2009). In addition, the basin experiences a high flood coefficient. 70% of the total flow of the Tassaout basin (upstream of the Moulay Youssef dam), which generates significant surface runoff after precipitation.
- Period of low water (Base-flow), which experiences a significant flow, despite the scarcity of precipitation during this period. This can be explained by the slow draining reservoir (El Ghachi, 2007) representing 35% in total of the flow of the Tassaout basin (upstream of the Moulay Youssef dam), which plays an important role in supporting the flows in summer and at the beginning of autumn (Monk. 2008). We can well specify the hydrological balance variables according to the results of the following table :

Table 3 Monthly hydrological balance of the Ait Tamlil catchment (1986-2010)

	J	F	M	A	M	J	JT	A	S	O	N	D	
Precipitation (P)	91	85	89	59	48	17	5	14	30	52	70	71	631
Debit M3/S	8,3	10,3	14,4	15,5	10,2	7,1	5,1	4,7	4,8	5,3	5,5	6,6	8,1
N Days / Month	31	28,25	31	30	31	30	31	31	30	31	30	31	365,3
UsefulPrecipitation (Pu)	87	82	85	58	47	17	5	14	30	51	68	69	613
Etp	12	20	30	55	85	132	186	166	110	69	28	15	908
RainfallDeficit (Dp)	-75	-62	-55	-3	38	115	181	152	80	18	-40	-54	
DpCumulated	0	0	0	0	38	153	334	486	566	584	11	0	
R (State Of The R)	50	50	50	50	23	2	0	0	0	0	32	50	
Dr (Reserve Variation)	0	0	0	0	-27	-21	-2	0	0	0	32	18	
Etr	12	20	30	55	74	38	7	14	30	51	28	15	374
Needs (Etp-Etr)	0	0	0	0	11	94	179	152	80	18	0	0	534
Surplus Of The Water Balance	75	62	55	3	0	0	0	0	0	0	8	36	239
Transfer (Tr)	10	9	20	22	10	7	4	4	6	9	9	10	120
Q Tablecloth	21	22	34	35	22	17	13	13	14	16	16	18	241
Q Raw	11	16	19	18	15	12	10	8	7	7	7	7	136
Flood Flow Coefficient (Cec)	0,12	0,18	0,21	0,30	0,31	0,70	1,97	0,60	0,24	0,13	0,10	0,10	
Water Withdrawn (Pr)	3,00	3,00	3,00	3,00	3,00	3,00	4,40	4,90	5,50	5,50	5,50	4,00	48
Simulated Flow	29	35	50	50	34	26	18	16	16	17	17	21	329
Measured Flow	28	32	50	52	35	24	17	16	16	18	18	23	329
Fault (%)	5	8	0	-4	-4	8	9	3	-2	-4	-4	-9	0

Table 4 Monthly hydrological balance of the Tamsemat catchment (1986-2010)

	J	F	M	A	M	J	JT	A	S	O	N	D	
Precipitation (P)	94	89	88	67	50	15	9	12	37	66	83	86	696
Debit m3/s	3,3	4,7	6,0	5,4	4,4	3,3	2,3	2,1	2,7	3,2	3,6	4,1	3,8
n days / month	31	28,25	31	30	31	30	31	31	30	31	30	31	365,3
Useful precipitation (Pu)	88	84	83	65	49	15	9	12	37	64	79	82	667
ETP	7	14	29	45	72	120	167	151	92	58	21	10	786
Rainfall deficit (DP)	-81	-70	-54	-20	23	105	158	139	55	-6	-58	-72	
DP Cumulated	0	0	0	0	23	128	286	425	480	106	0	0	
R (state of the R)	50	50	50	50	32	4	0	0	0	3	31	50	
DR (reserve variation)	0	0	0	0	-18	-28	-4	0	0	3	28	19	
ETR	7	14	29	45	67	43	13	12	37	58	21	10	356
NEEDS (ETP-ETR)	0	0	0	0	5	77	154	139	55	0	0	0	430
SURPLUS of the water balance	81	70	54	20	0	0	0	0	0	3	30	53	311
Transfer (Tr)	-20	-21	-12	-7	-4	-5	-7	-4	0	0	0	-5	-85
Q tablecloth	3	6	17	21	20	16	12	13	15	13	14	13	163
Q raw	17	16	16	9	5	3	2	1	1	3	8	12	92
Flood flow coefficient (Cec)	0,18	0,18	0,18	0,13	0,09	0,19	0,20	0,11	0,03	0,05	0,09	0,14	
Water withdrawn (Pr)	1,50	1,50	2,00	2,50	2,50	2,50	3,00	3,50	4,00	3,50	3,50	3,00	33
simulated flow	18	21	31	27	22	16	11	11	12	12	18	22	222
measured flow	16	21	30	27	22	16	11	11	13	16	18	21	222
fault (%)	15	-2	2	1	1	2	-1	-1	-7	-22	2	4	0

Table 5 Monthly hydrological balance of the Tassaout basin (upstream of the Moulay Youssef dam) (1986-2010)

	J	F	M	A	M	J	JT	A	S	O	N	D	
Precipitation (P)	92	85	89	63	49	16	8	14	33	58	77	79	663
Debit M3/S	11,5	14,9	20,4	21,0	14,6	10,4	7,3	6,8	7,5	8,5	9,2	10,7	11,9
N Days / Month	31	28,25	31	30	31	30	31	31	30	31	30	31	365,3
Useful Precipitation (Pu)	88	82	85	62	48	16	8	14	33	57	75	76	644
Etp	10	17	30	50	78	126	177	159	101	64	24	12	848
Rainfall Deficit (Dp)	-78	-65	-55	-12	30	110	169	145	68	7	-51	-64	
Dp Cumulated	0	0	0	0	30	140	309	454	522	529	0	0	
R (State Of The R)	50	50	50	50	27	3	0	0	0	0	15	34	

Dr (Reserve Variation)	16	0	0	0	-23	-24	-3	0	0	0	15	19	
Etr	10	17	30	50	71	40	11	14	33	57	24	12	369
Needs (Etp-Etr)	0	0	0	0	7	86	166	145	68	7	0	0	479
Surplus Of The Water Balance	62	65	55	12	0	0	0	0	0	0	36	45	275
Transfer (Tr)	0	2	6	10	5	0	-2	-2	3	4	4	4	34
Q Tablecloth	8	11	16	19	13	7	5	4	8	9	9	10	119
Q Raw	20	25	27	26	21	17	14	12	10	9	12	15	209
Flood Flow Coefficient (Cec)	0,22	0,29	0,31	0,41	0,42	1,09	1,79	0,87	0,31	0,16	0,15	0,19	
Water Withdrawn (Pr)	2,25	2,25	2,50	2,75	2,75	2,75	3,70	4,20	4,20	4,50	4,25	3,50	40
Simulated Flow	26	34	41	42	31	22	16	12	14	14	17	22	288
Measured Flow	24	28	42	42	30	21	15	14	15	17	18	22	288
Fault (%)	6	20	-3	0	3	3	4	-15	-6	-20	-8	-2	0

5. Discussion

The Tassaout basin (upstream of the Moulay Youssef dam) is characterized by significant water resources, according to the runoff coefficient which reached 43% of the amount of precipitation during the statistical series (1986-2010). For the results, we included all the variables studied (precipitation, potential ETP evapotranspiration, real ETR evapotranspiration, flow, reserve state R…) According to the model used to develop the hydrological balance. The monthly flow regime of the study basins can be determined by marking the following:

- This article allowed us to make a synthesis of hydrological modelling and the stages of the implementation of a hydrological model.
- The choice of the Orchy II hydrological model is justified by the climatic data available (model inputs), that it is a simple conceptual model with few parameters, but associated with a measurable physical reality, and which can integrate anthropogenic impact on hydrological functioning (El Ghachi. 2014).
- Hydrological functioning varies in the three basins, both at the annual and monthly scales.
- The Tassaout basin (upstream of the Moulay Youssef dam) receives significant rainfall during the period between November and March with a spatial variation between upstream and downstream of the basin (Boudhar 2009).
- The study basins are characterized by a very significant flood flow, representing 60% for the Tassaout basin (upstream of the Moulay Youssef dam) and 36% for the Ait-Tamlil and Tamsemat catchments. This type of rapid flow, which helps to fill the sub-surface soil reservoir, is more sensitive to evaporation (Guigo. 1975)
- The rate of the groundwater flow varies between 40 and 70% of the total flow for the three basins, contributes to the flow during the summer period, when rainfall decreases (Castany. 1968).
- The correlation coefficient which marked values over 0,95, reflects very satisfactory results for the simulated flow, either at the monthly or annual level.
- The OrchyII model has proven its effectiveness in analyzing the elements of the water balance and highlighted the anthropogenic impact on the hydrological functioning of the basin, where water water samplings represent 14% of the annual modulus. This proportion worsens during the summer periods of the year.
- The representation of the hydrological balance on a monthly scale made it possible to consider the impact of changes in anthropogenic forcing on flows.

6. Conclusion

The climatic and hydrological study has shown that the basin has great hydrological potential, the regime of which is greatly influenced by human activities, from a network of canals through which a large quantity of irrigation water is transferred.

To simulate a rain-flow model for a better understanding of the hydrological behaviour of the Tassaoute basin (upstream of the Moulay Youssef dam); we have started to apply the OrchyII model to the monthly time step, which has proven its effectiveness in analyzing water balance parameters and in pinpointing the influence of natural and human factors. Water sampling represent around 14% of the total annual flow of the study basins, which clearly influences the hydrological functioning of the basin.

Acknowledgment

We extend our sincere thanks to the management services of the Oum Er Rabia river Basin Agency, for hydro-climatic data, Mr El-Haqqani Bouchaib, Mr Mernoun Ahmed, Mr Ibrahim Aghzaf and Mr Lkhider

Ahmed. We would also like to thank the management services of the Provincial Directorate of Agriculture at Azilal for the provision of irrigation data in the basin.

Bibliography

[1] ABHOER, (1972). Étude hydrologique de l'OUM ER RBIA Rapport, 501 pp.

[2] Alley. M.W. (1985). Water balance models in one-month-ahead stream flow forecasting. Water ressource research 21(4), 597-606.

[3] Boudhar. A. (2009). Télédétection du manteau neigeux et modélisation de la contribution des eaux de fonte des neiges aux débits des Oueds du Haut Atlas de Marrakech Thèse de doctorat de 3ème cycle. Université Cadi Ayyad Faculté des sciences et Techniques- Marrakech. Maroc. p232

[4] Castany G. (1968). Prospection et exploitation des eaux souterraines. Paris. Dunod, 717 p.

[5] Couvreur. G. (1988). Essai sur l'évolution morphologique de haut atlas calcaire – Maroc. Notes et Mémoires du Service Géologique. Edition du Service Géologique du Maroc N° 318. 391 p.

[6] Direction Provinciale d'Agriculture d'Azilal (DPAA). (2014). Étude d'inventaire et de la caractérisation des périmètres existants de la PMH et identification des possibilités de l'extension par l'irrigation des périmètres associés aux petits et moyens barrages par bassins hydrauliques Rapport. 45p

[7] Dubreuil. P. (1974). Initiation à L'analyse Hydrologique. Université de Paris VI. ORSTOM. 216 p.

[8] El Ghachi. M. (2007). La seille : un système fluvial anthropisé (lorraine. France) Tome 1. Thèse de doctorat de 3ème cycle. Université Paul Verlaine de METZ. France .344p.

[9] El Ghachi. M. (2014). Élaboration d'un bilan hydrologique. Méthodologie et Application. Le cas de la Seille (Lorraine. France). revue FLSH Beni-mellel. 15 p.

[10] El Khalki. Y. (1990). Étude hydrogéomorphologique du haut Sebou. cas de synclinal de Skoura et de ses bordures (Moyen Atlas. Maroc). Thèse de Doctorat. Université d'Aix Marseille II. Tome I. France. 244 p.

[11] Gille. E. (1985). Contribution à l'étude hydrologique des bassins de la Meuse et de la Moselle. Problématique de l'utilisation d'un modèle couplé à discrétisation spatiale Thèse de doctorat de 3ème cycle. École Nationale Supérieure des Mines de Paris et Université Pierre et Marie Curie. 213 p.

[12] Gille. E. Lang. C. (2004). Problématique d'optimisation des paramètres de calage d'un bilan hydrologique. Application aux bassins versants de la Sauer. Mosella. Tome XXVIII-N°1-2. 157-172 pp.

[13] Guigo. M. 1975. Essai de bilan hydrologique sur un petit bassin versant de l'Apennin padan. Le Parma. Revue Géographique de l'Est. 15-1-2. Pp. 63-87.

[14] Makhlouf. Z. (1994). Compléments sur le modèle Pluie-Débit GR4J, essai d'estimation de ses paramètres. Thèse de doctorat. Université Paris XI Orsay. France. 426 p.

[15] Moine. N. (2008). Le bassin versant de surface vue par le souterrain. une voie d'amélioration des performances et du réalisme des modèles pluie-débit. Université Pierre et Marie Curie. École Doctorale 398 Géosciences et Ressources Naturelles. Thèse de doctorat de 3ème cycle. 348 p.

[16] Mouhdi. A. (1993). Contribution à l'étude pluvio-hydrologique du bassin-versant de l'oued Melloulou (Maroc oriental). Université des sciences et technologies de Lille U.F.R. de géographie et d'aménagement spatial. Thèse de doctorat de 3ème cycle. 251 p.

[17] Perrin. C. (2000). Vers une amélioration d'un modèle global pluie-débit au travers d'une approche comparative. Thèse de doctorat, INPG, Grenoble. 287 p.

[18] Qadem. A. (2015). Quantification. Modélisation et gestion de la ressource en eau dans le bassin versant du haut Sebou (Maroc). Université Sidi Mohamed Ben Abdelah et Université de Lorraine. Thèse de Doctorat de 3ème cycle. Maroc. 360 p.

[19] Riou. C . (1975). la détermination de l'évaporation. Application à l'Afrique. Mémoire ORSTOM, 236 p.

[20] Strahler, A. N. (1957). Quantitative analysis of basin geomorphology American Geophysical Union Transactions 38(6). 912-920.

[21] Thornthwaite. C.W. et Mather. J.R. (1957). Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance. Drexel Institute of Technology. Laboratory of Climatology. Publications in Climatology 10(3). 311 pp.