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Climate change scenario and water/nutrient balance response in a semi-arid catchment (Merguellil-Tunisia)

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INTRODUCTION

Climate change is one of the greatest environmental, social and economic threats the planet is facing. Water is potentially one of the most affected resources as climate changes. Nowadays, all over the world and particularly in the Mediterranean countries, water resources are confronting serious problems related to their quantity and quality.

In this study, the Soil and Water Assessment Tool (SWAT-2000) model has been applied to a typical Mediterranean semi-arid catchment (Merguellil, Tunisia). The water and nutrient balance have been simulated, The potential effects of climate change scenarios on hydrological response and water quality dynamics have been investigated.

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STUDY SITE

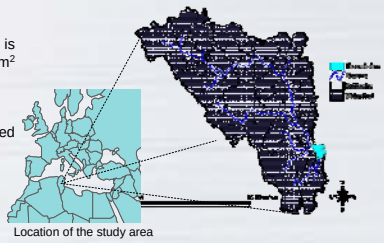
Merguellil basin is located in the central part of Tunisia and is characterized by a semi-arid climate. It covers an area of about 1200 km^2 upstream of the El Haouareb dam built in 1989 over a rocky sill.

The river net has an overall length of around 158 km
The water stress situation in the Merguellil catchment can be summarized as a limited resource facing an increasing water demand.

Diversified conditions of geology, morphology, vegetation and land use

The cropping pattern is mostly dominated by the durum wheat(41%)

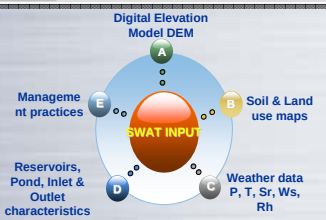
The dominant soil types are silty loam, and clay loam.



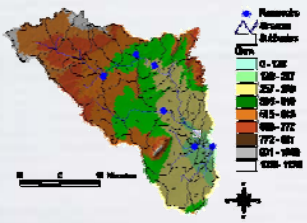
Location of the study area

METHODS

The SWAT hydrological model has been used which is a process-based continuous daily time-step model (Arnold *et al*., 1998).

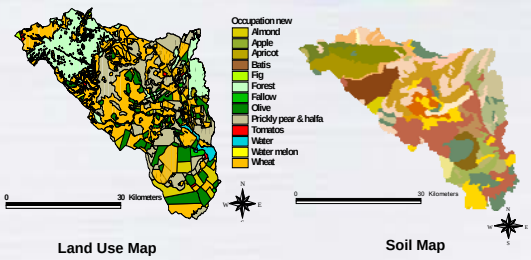


1 Watershed delineation



34 sub-basins

2 Overlapping the land use & soil maps



205 HRUs * HRU: Hydrological Response Units

Results

Water balance has been calculated on basin scale.
Hargreaves Montheith method has been selected for estimating potential evapotranspiration

Simulation steps

- A — Simulation 1985-2005
- B — Warm up the model 1985-1991
- C — Calibration 1992-1994
- D — Validation 1996-1997

1 Water balance result

Table . Average monthly basin values (1985-2005)

	RAIN (MM)	SURF Q (MM)	LAT Q (MM)	FLOW (MM)	ET (MM)	PET (MM)
January	34.85	4.21	0.09	4.32	13.09	45.64
February	24.88	3.88	0.08	4.07	16.45	58.84
March	34.44	3.60	0.10	3.83	33.04	90.83
April	23.98	1.61	0.08	1.88	38.81	120.93
May	28.71	1.29	0.08	1.49	44.22	167.97
June	15.94	0.91	0.06	1.01	41.57	199.14
July	5.09	0.11	0.03	0.15	20.46	219.96
August	18.7	1.14	0.04	1.18	16.96	198.20
Septembe r	43.29	2.40	0.09	2.48	20.55	136.03
October	30.75	1.94	0.1	2.03	17.39	95.06
Novembe r	26.07	1.94	0.07	2.02	13.68	57.06
Decembe r	24.76	2.75	0.08	2.84	12.22	43.13
Annual	311.46	25.75	0.90	27.30	288.53	1433.50

Hydrological balance dominated by evapotranspiration (91%)

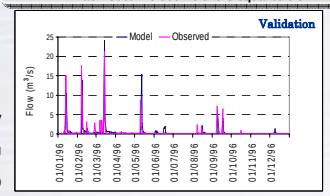
Average monthly flow is maximum in January, February and March. Minimum in July.
Lateral flow is low and it remains almost constant during the year.
During some years, the flow in the summer period is 0 "Intermittent river" .

2 Steam flow result

Simulated stream flow were compared to the observed on a daily time step at Hafouz flowgage.

Calibration — Input parameters were adjusted so that measured flow match values predicted by the model during this period

Validation — The measured daily stream flow concentrations match more or less values predicted by the model during this period, without adjusting any input parameter value. The model performance was satisfactory. Nash-Sutcliffe coefficient is equal to 0.5

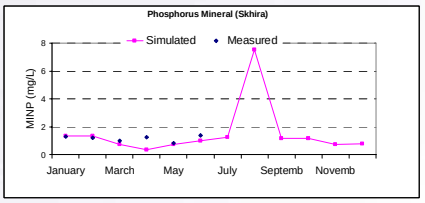


Validated Vs measured flow in Hafouz station

3 Quality result

Regarding the pollutant concentrations, measured and simulated water quality in the river have been compared.

Sediment and nutrients loads have been evaluated in different stations.



Simulated Vs Measured Phosphorus Mineral

Phosphorus simulated concentrations presented a better convergence in relation to existing measurements

CLIMATE CHANGE SCENARIO

A prediction has been done for the year 2020, 2050 and 2080.

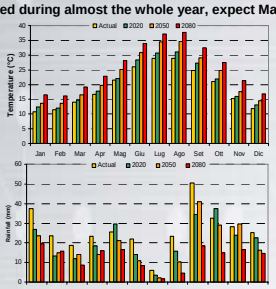
The general circulation model HadCm3, developed by UK Hadley Center for climatic prediction and research, has been used to estimate changes in the precipitation and temperature for 2020, 2050, and 2080.

The SWAT model has been used to evaluate the impact of the climatic change to the water availability in the Merguellil catchement

Substantial changes are expected in water and nutrient balance, both as annual or monthly values.

The HadCm3 predicts in the Merguellil catchment an increase in the average annual temperature of 1.36°C by 2020, 3.62 °C by 2050, and 6.5°C by 2080.

For the year 2020, on a monthly basis, a decrease in precipitation is predicted during almost the whole year, expect May, and October.

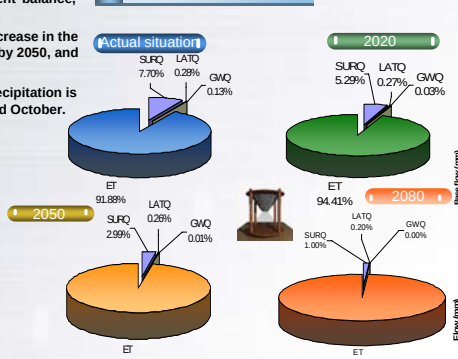


1 Yearly change

All the components of the water and nutrient balance are foreseen to decrease in a yearly scale

	RAIN (MM)	SURF Q (MM)	Base flow (MM)	FLOW (MM)	ET (MM)	PET (MM)	TSL (t/ha)	N organic (kg/ha)	P Organic (kg/ha)
Actual	310	25.68	0.82	27.19	288	1432	1.02	2.12	0.24
2020	282	19.40	0. 47	20.50	268	1487	0.81	1.67	0.19
2050	238	11.47	0.08	12.35	236	1587	0.50	1.04	0.12
2080	165	4.31	0.01	4.68	175	1696	0.21	0.43	0.05

2 Water balance



The percentage of evapotranspiration will continuously increase over the next eight decades, according to the rise of temperature.

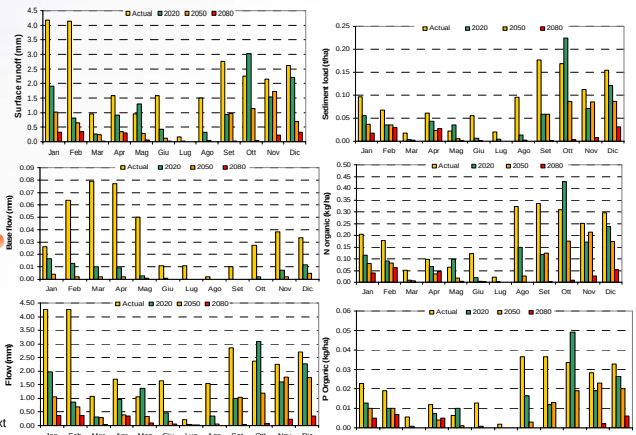
3 Hydrological result : Monthly change

The monthly flow would decrease continuously except on May and October

4 Quality result : Monthly change

A decrease in the monthly sediment loading is foreseen as a consequence of runoff surface decrease except in May and October 2020

Similar behavior is predicted for organic N and P



CONCLUSION

Swat model has been applied to the Merguellil catchment. The water and nutrient balance have been evaluated.

The results of the scenario, have shown that the climate change would have an impact on the quantity and quality of the surface runoff. Accordingly, a longer arid period in summer will lead to a decrease of the sediment and nutrient load in that period.

In October 2020, it is predicted an important increase in the precipitation, which result in an increase of the surface runoff and flash flood events.

In consequence, the sediment and nutrient load will have an important increase.

Further more, In the last decade, It has been demonstrated (De Girolamo *et al*., 2008) that an increase for the R-B index over time indicates an increasing flashy character to imply a very quick response to rainfall.

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