Hydrological And Water Quality Modeling For Alternative Scenarios In A Semi-arid Catchment

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Outline

- Problem statement
- Study area
- Results & discussion
- Alternative scenarios
- conclusion

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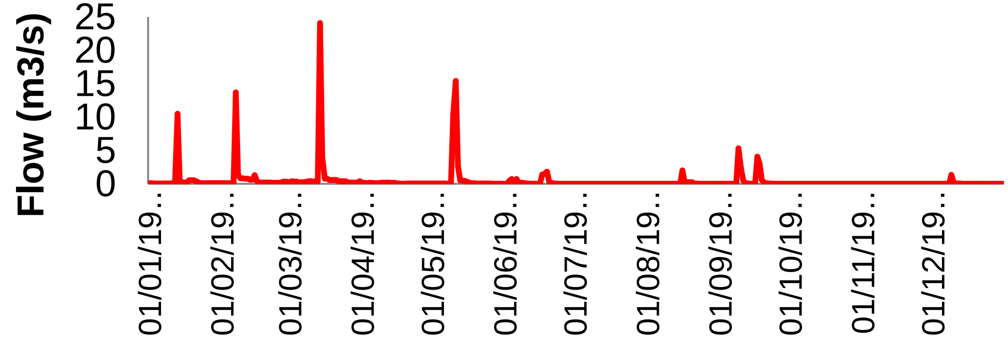
Introduction

Problem statement



Runoff less predictable
Difficulty for the monitoring

Drought

The Mediterranean basin has already been recognized as one of the most vulnerable regions in the world to climate change (IPCC, 2007).

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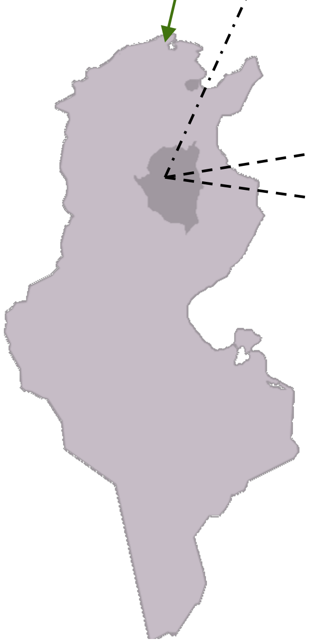
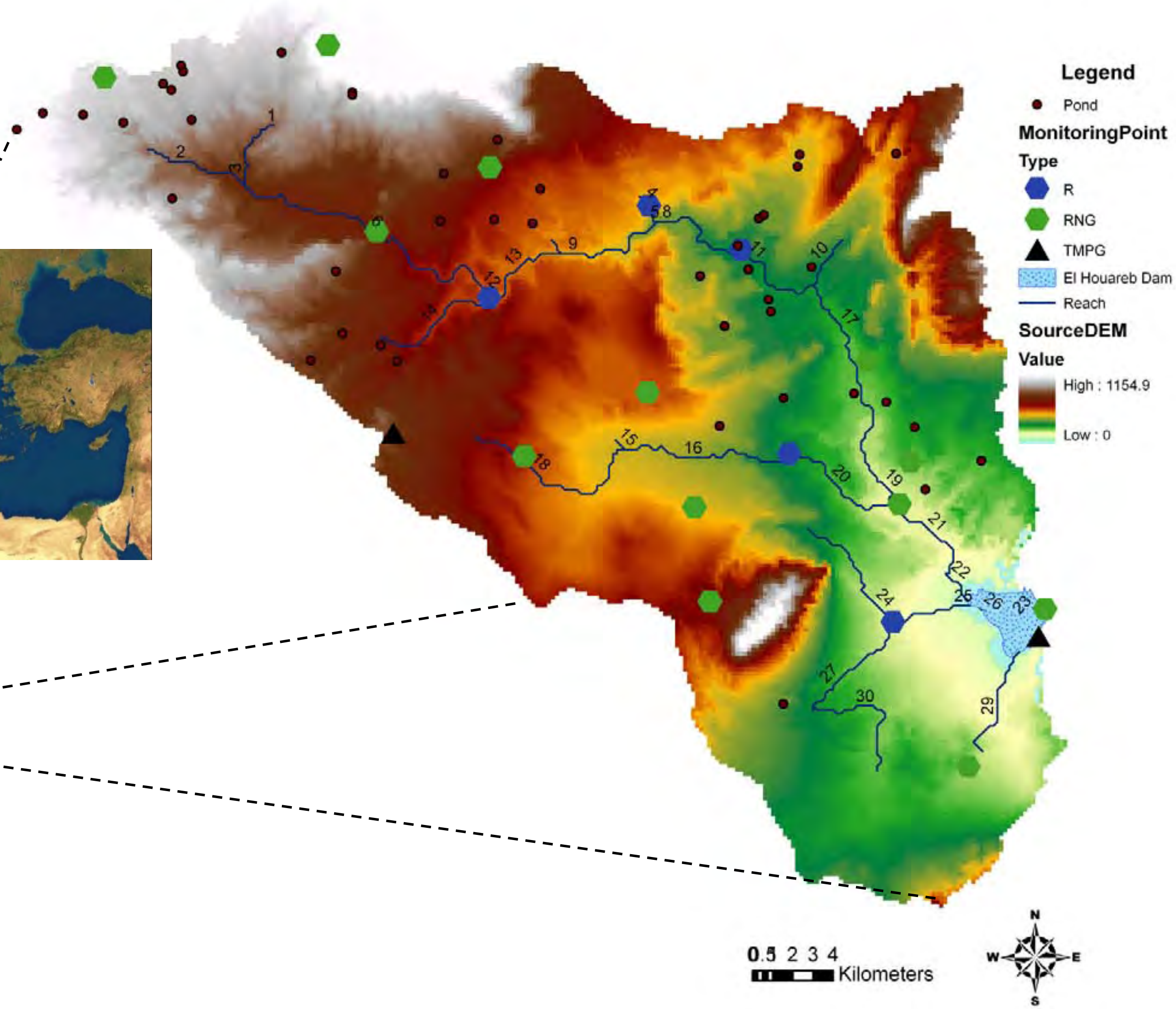
Study area

Tunisia





Merguellil catchment

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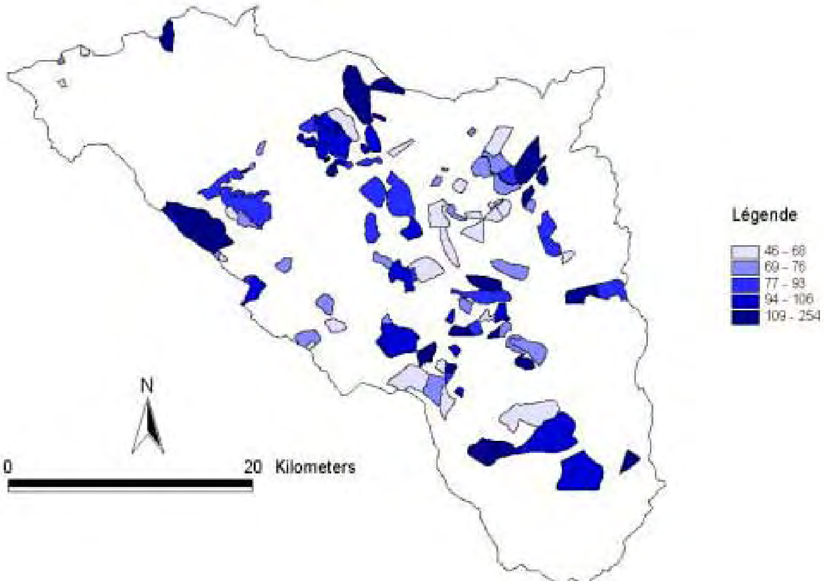
Study area: Soil & water conservation works (Reservoirs, Ponds, & contour ridges)



Spatial repartition of water storage capacity (mm) of the contour ridges

Contour ridges at the Hafouz region

El Morra Dam

El Maiz Pond

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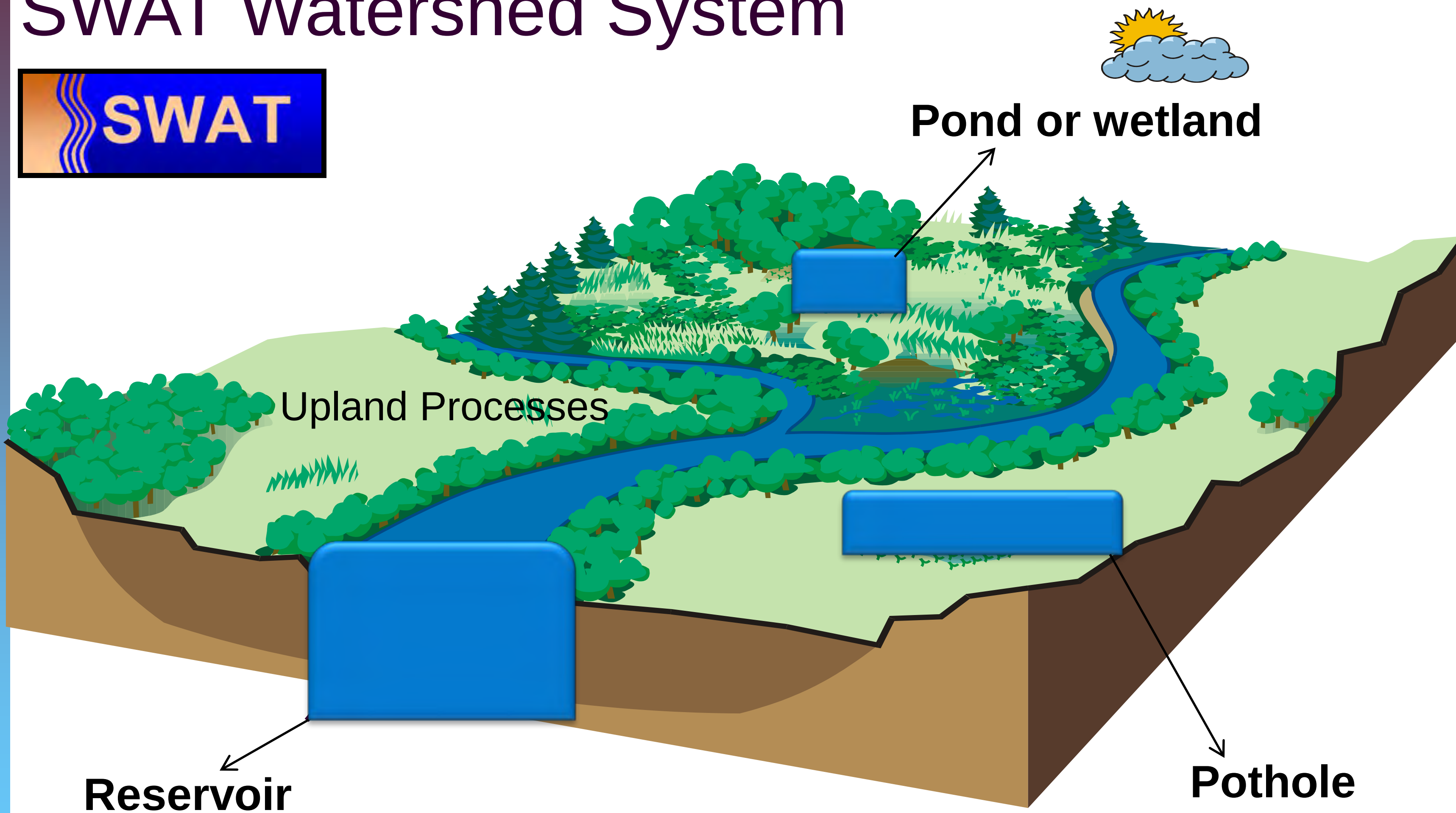
SWAT Model– Water bodies

SWAT Watershed System



Channel/Flood Plain
Processes

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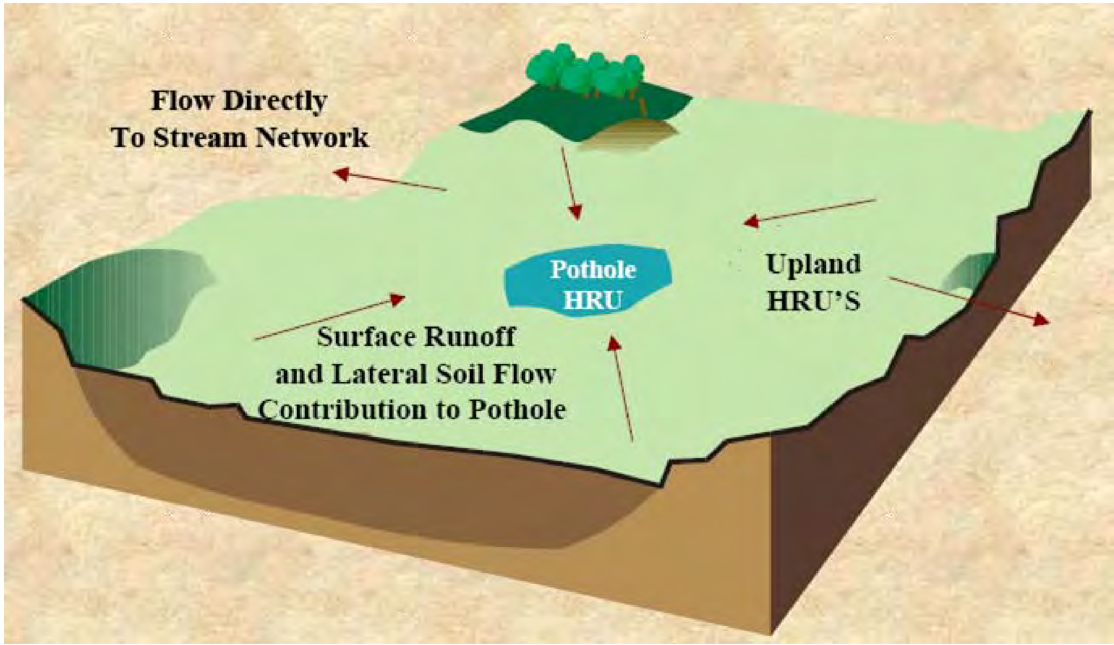
SWAT Model :Pothole as contour ridges



Location of pothole and hydrologic response Unit in the landscape (Du et al., 2005)

The runoff generated within these HRUs flows to the lowest portion of the pothole rather than contributing to flow in the main channel. If the area with the benches is bigger than the HRU considered as pothole, the water entering the pothole may be contributed from other HRUs in the subbasin.

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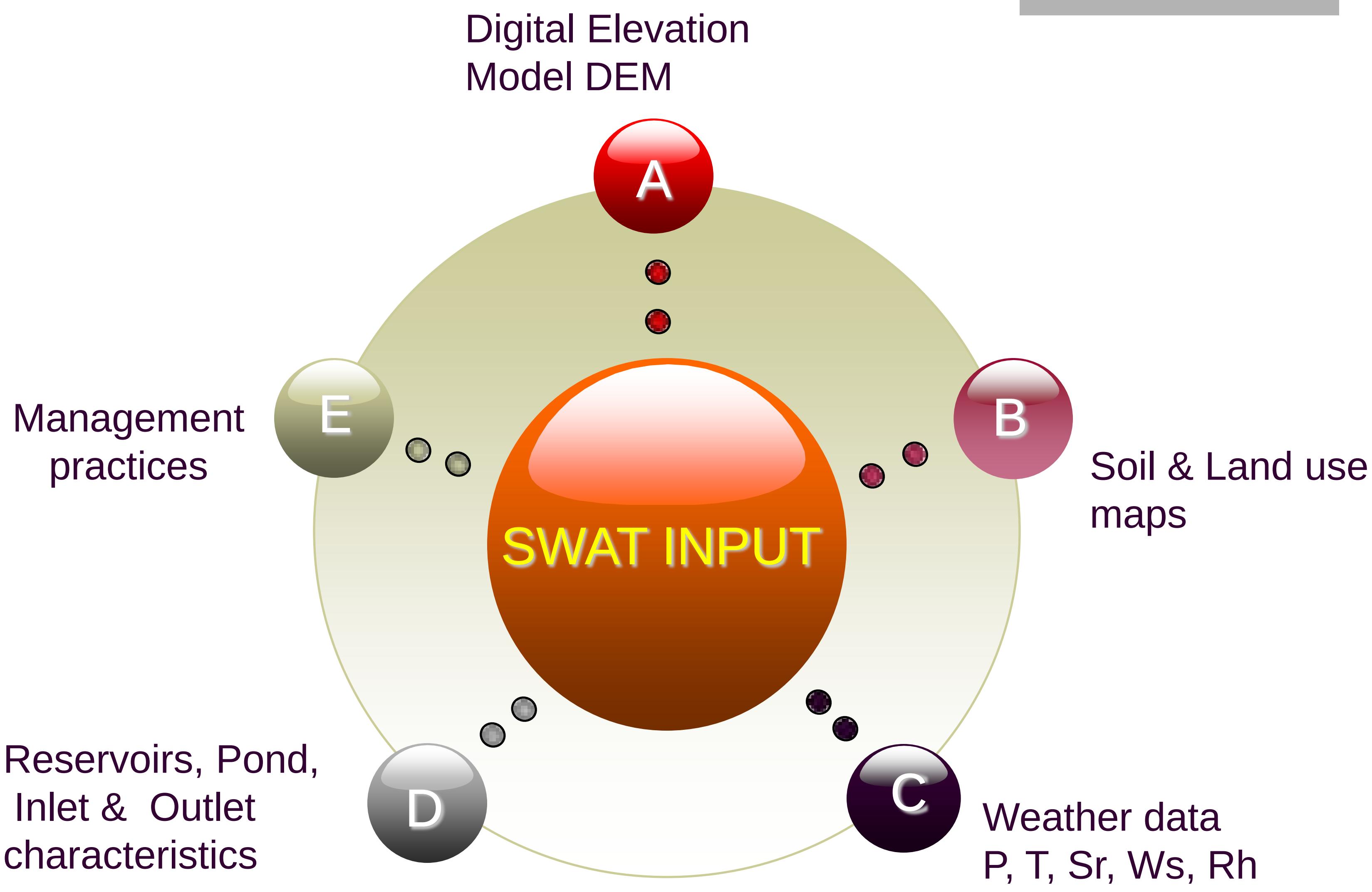
SWAT Model : Model Input



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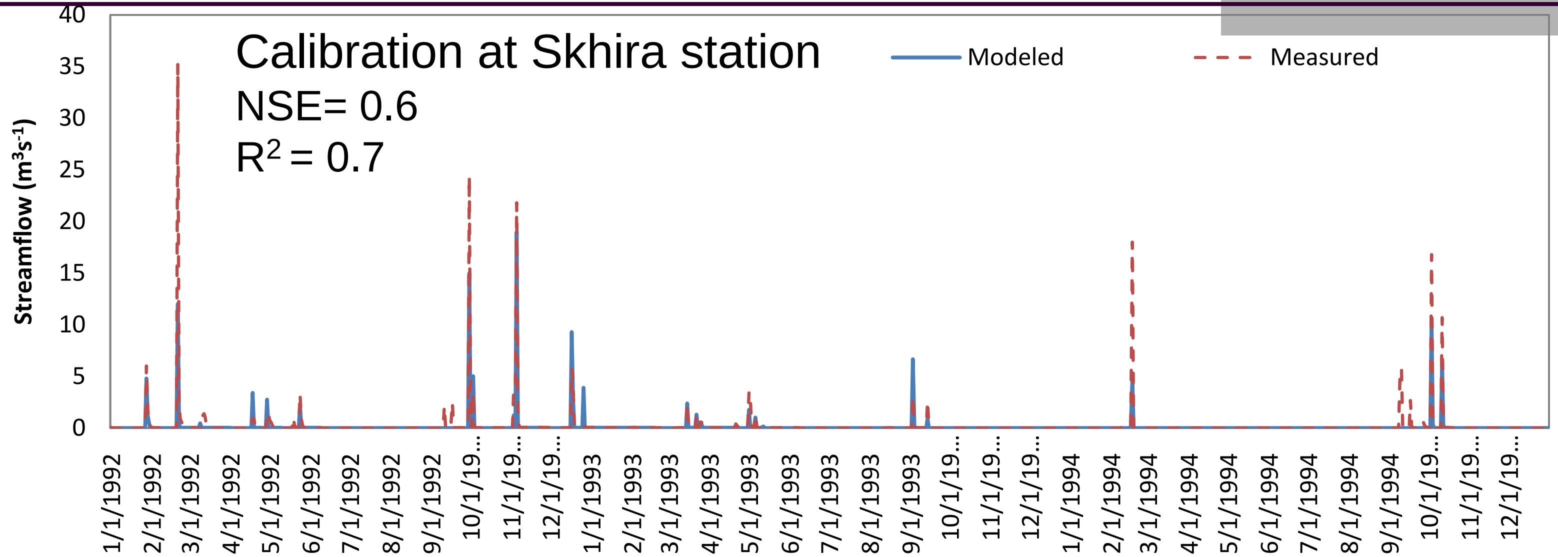
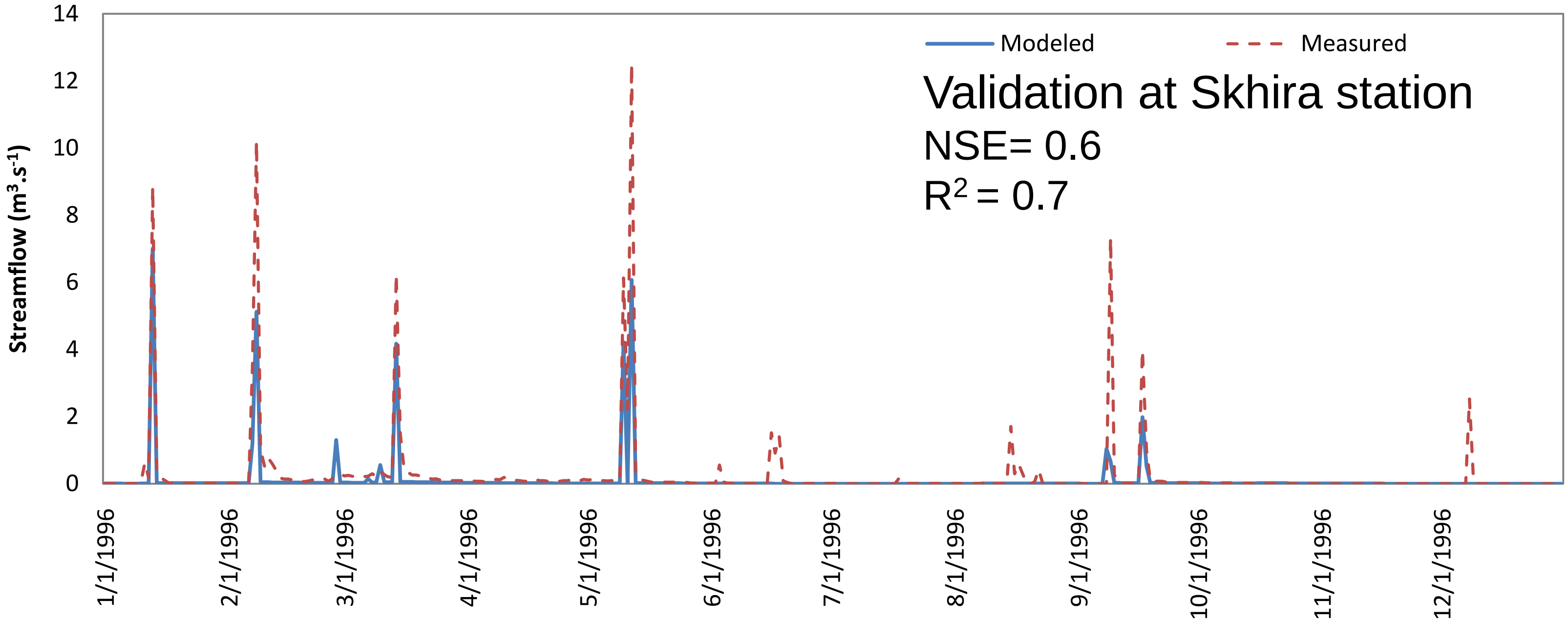
SWAT Result: Calibration & Validation





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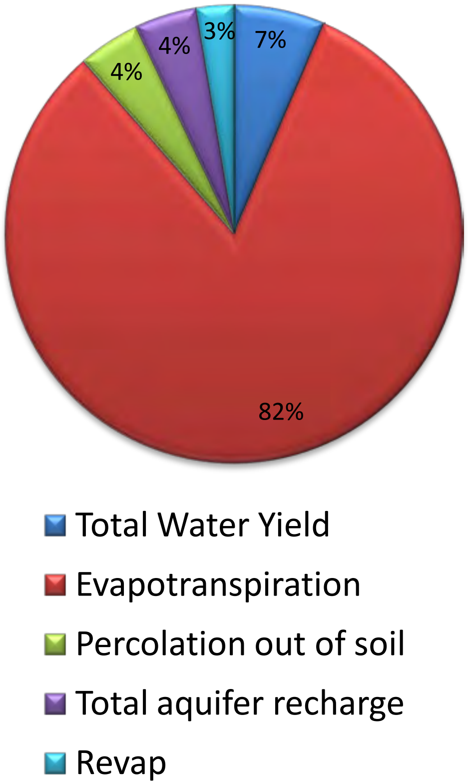
Water balance

MON	RAIN (MM)	SURF Q (MM)	LAT Q (MM)	TWY (MM)	ET (MM)	PET (MM)
1	41.15	3.96	0.17	4.28	12.43	45.48
2	27.75	3.28	0.13	3.92	16.15	58.86
3	29.5	2.66	0.14	3.44	26.68	92.07
4	25.35	1.08	0.1	1.9	45.5	120.09
5	28.79	0.5	0.1	1.27	53.86	169.49
6	15.38	0.14	0.08	0.73	31.52	200.91
7	4.75	0.04	0.04	0.43	14.47	220.49
8	20.19	0.38	0.06	0.65	16.15	197.98
9	49.28	0.7	0.13	0.98	22.31	134.78
10	33.47	0.97	0.13	1.28	18.62	96.13
11	27.54	0.74	0.09	1.06	12.7	57.07
12	26.33	1.85	0.1	2.22	11	43.08
Total	**329.48**	**16.3**	**1.27**	**22.16**	**281.39**	**1436.43**



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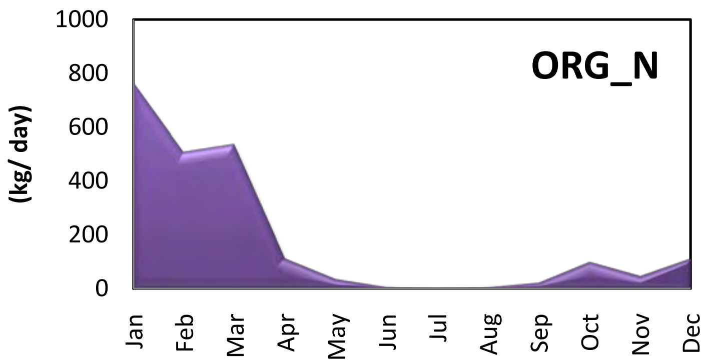
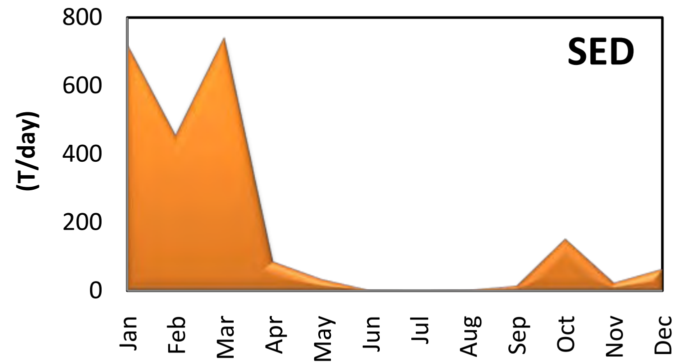
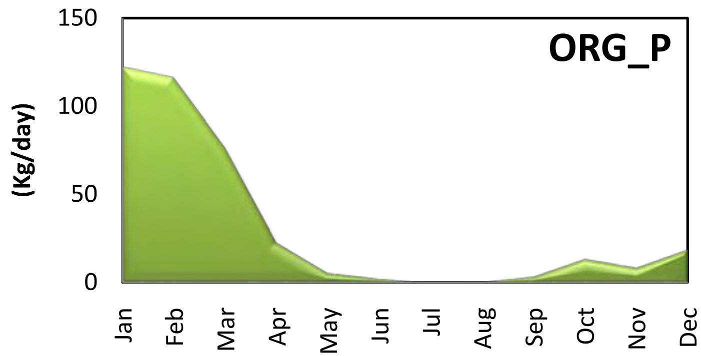
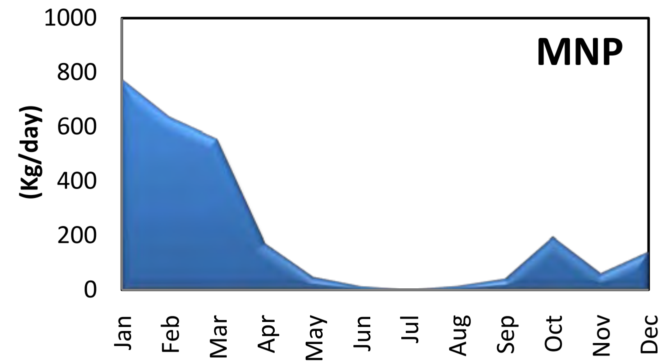
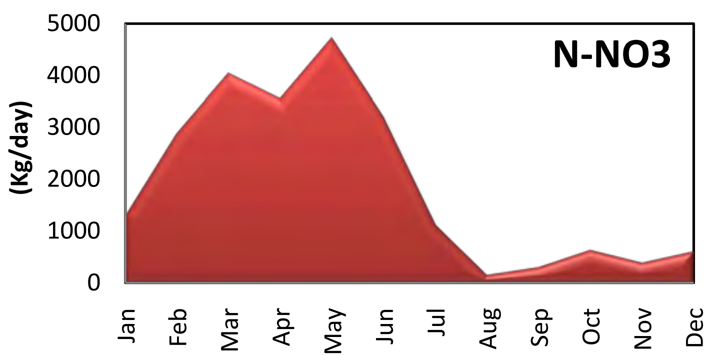
Water quality simulation











Average monthly loads simulated at the outlet for the period (1990-2005)

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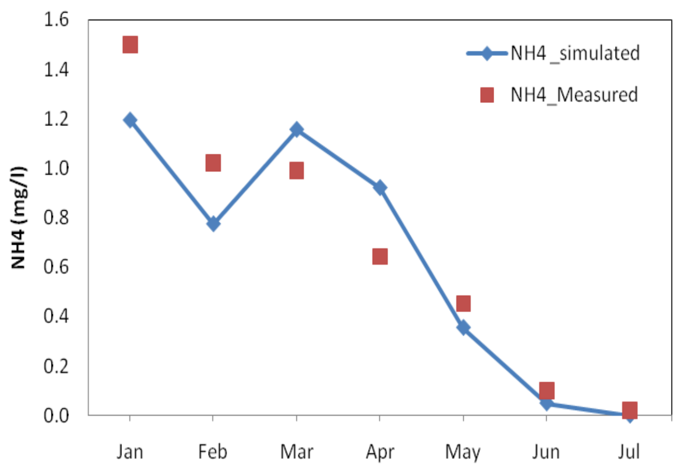
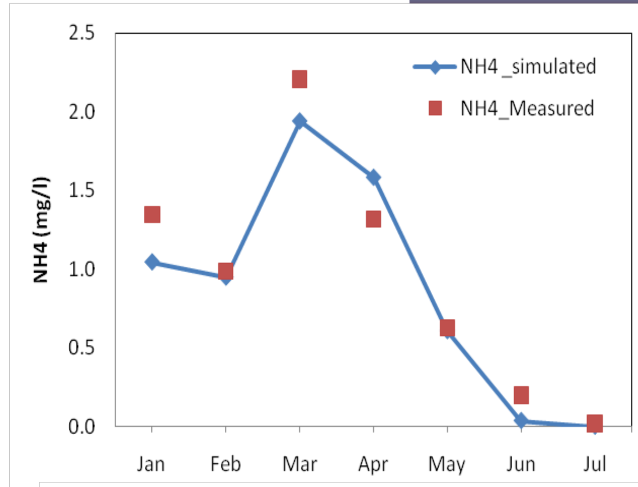
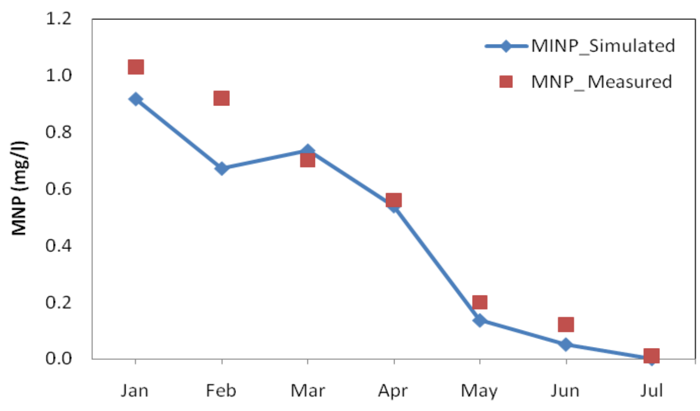
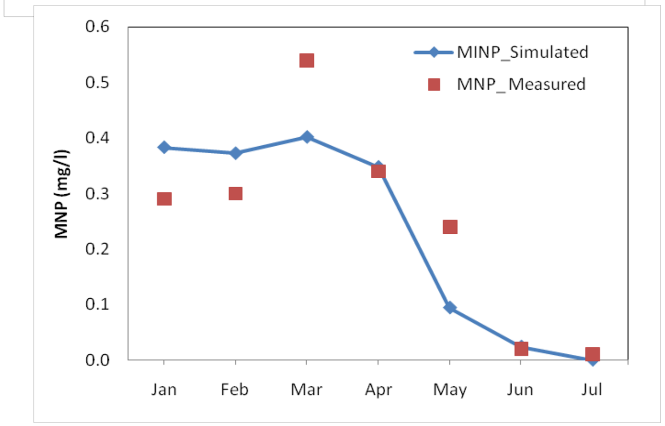
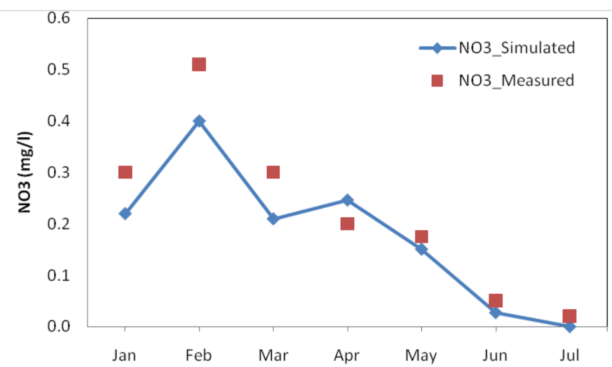
Water quality simulation











Measured virus simulated nutrients (Amoniac NH4 and minera phosphorus MNP at the Skhira (right) and kissra (left) stations.

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Scenario 1: 20% reduction of the fertilizer amount

Estimated effects of reduction fertilizer application on the crop yield.

CROP	Yield (T/ha)		Yield reduction
	Baseline	Scenario 1	%
Durum wheat	2.56	2.51	2.09
Olive	3.33	3.31	0.57
Almond	0.23	0.23	0.00

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Scenario 1: 20% reduction of the fertilizer amount

Estimated effects of reduction fertilizer application on nutrient loads.

	N-NO3 (T/year)			N total (T/year)			P total (T/year)		
	Baseline	Scenario1	% reduction	Baseline	Scenario1	% reduction	Baseline	Scenario1	% reduction
1996	116	111	4	242	236	3	74	62	16
1997	183	176	4	361	352	3	85	74	13
1998	28	25	11	35	32	9	5	4	20
1999	167	157	6	364	353	3	109	94	14
2000	35	32	9	43	40	7	6.2	5.4	13
Mean	106	100	6	209	202	3	56	48	14

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Scenario 2:Impact of potholes on water balance and sediment loading

Table: Impact of potholes on water balance and sediment loading

	Surface Q (mm)	TWY (mm)	Total AQR (mm)	Volume ($10^6 m^3$)	Sediment (T/ha)
No pothole	23.93	27.94	10.19	26	96740
With Pothole	16.22	22.05	15.42	19	71430
Change (%)	- 32	- 21	+ 50	-25	-26

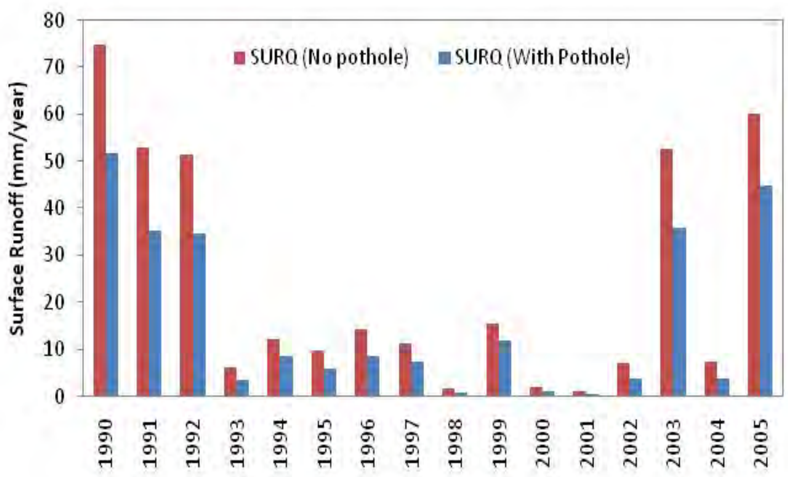

Figure . Impact of potholes on total Surface runoff

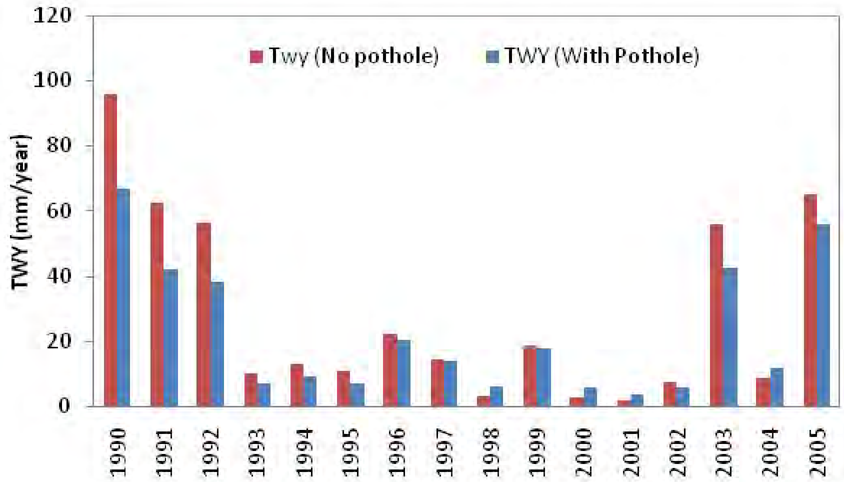

Figure . Impact of potholes on total water yield

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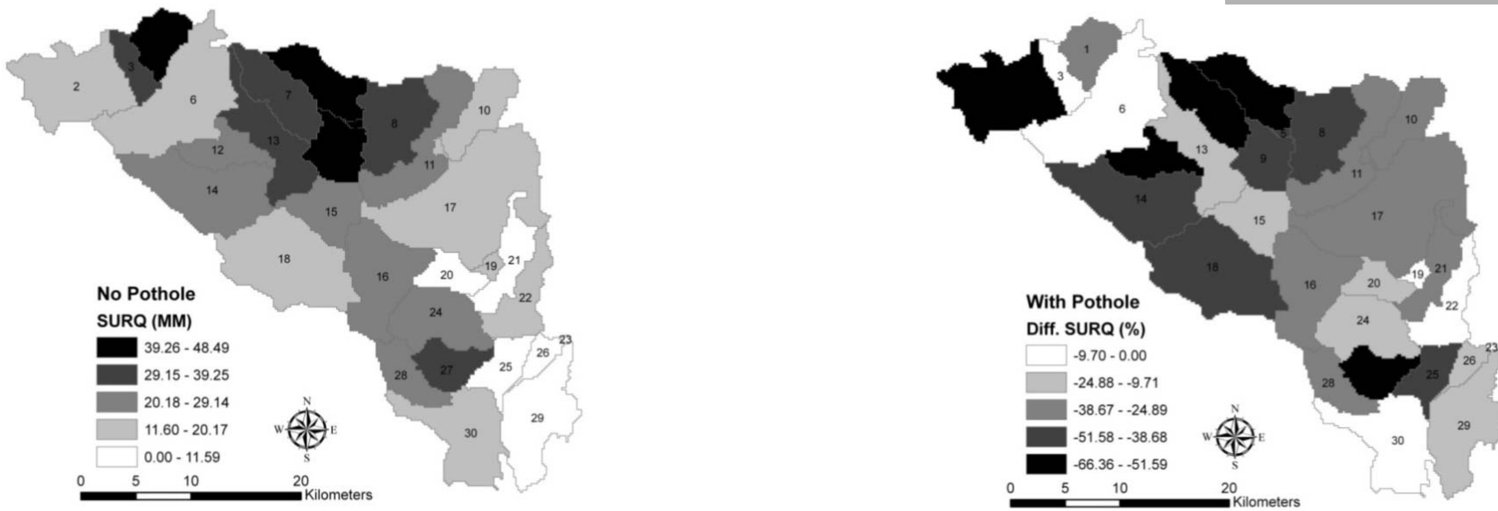
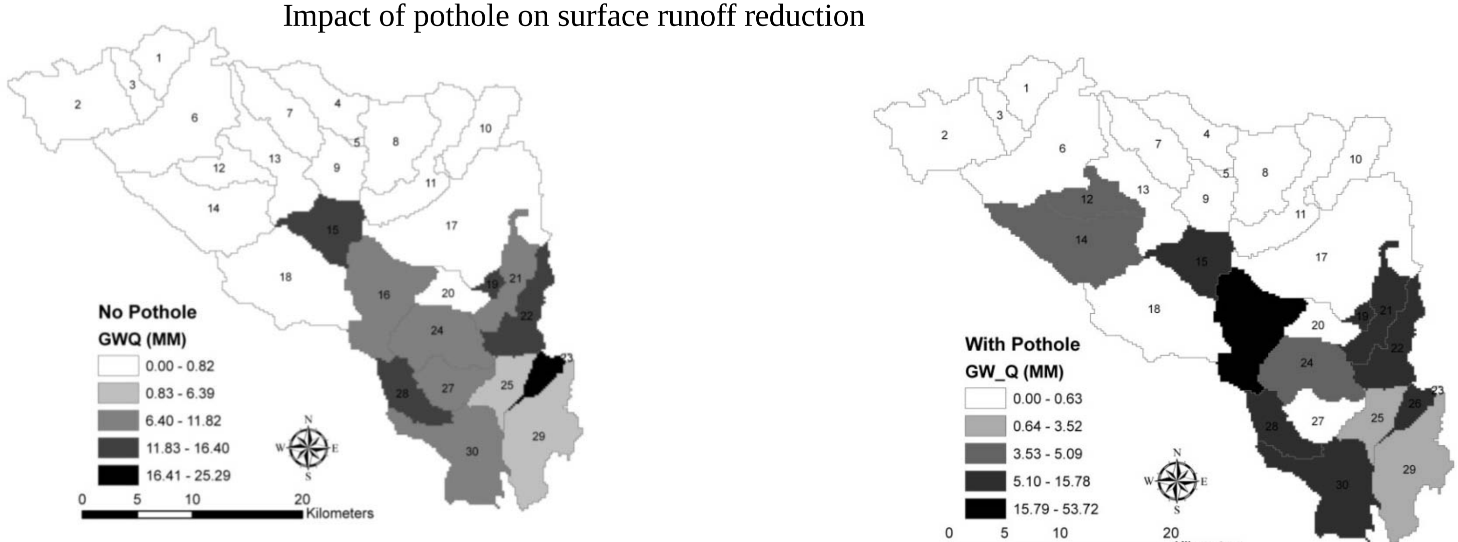
Scenario 2:Impact of potholes on water balance and sediment loading



Impact of pothole on surface runoff reduction



Impact of pothole on groundwater

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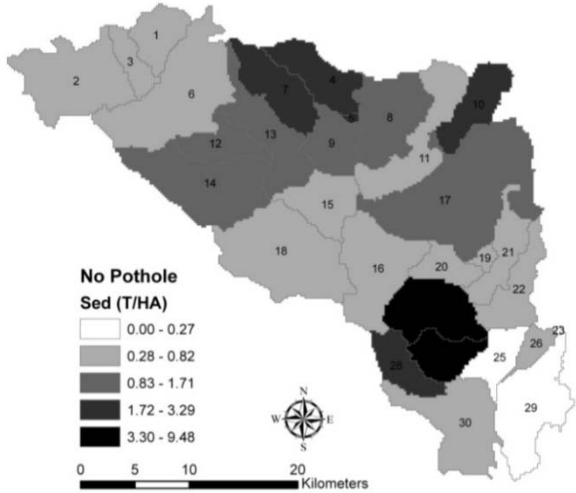
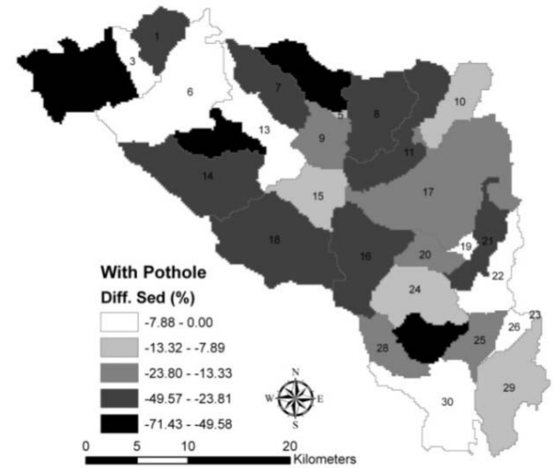
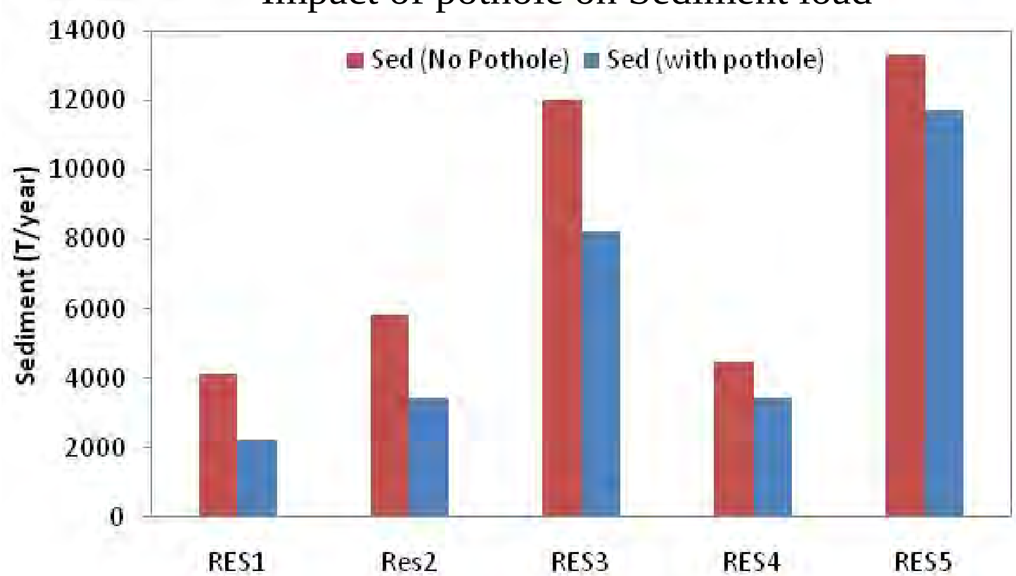
Scenario 2:Impact of potholes on water balance and sediment loading





Impact of pothole on Sediment load



Impact of potholes on sediment retention in the five reservoirs within the watershed

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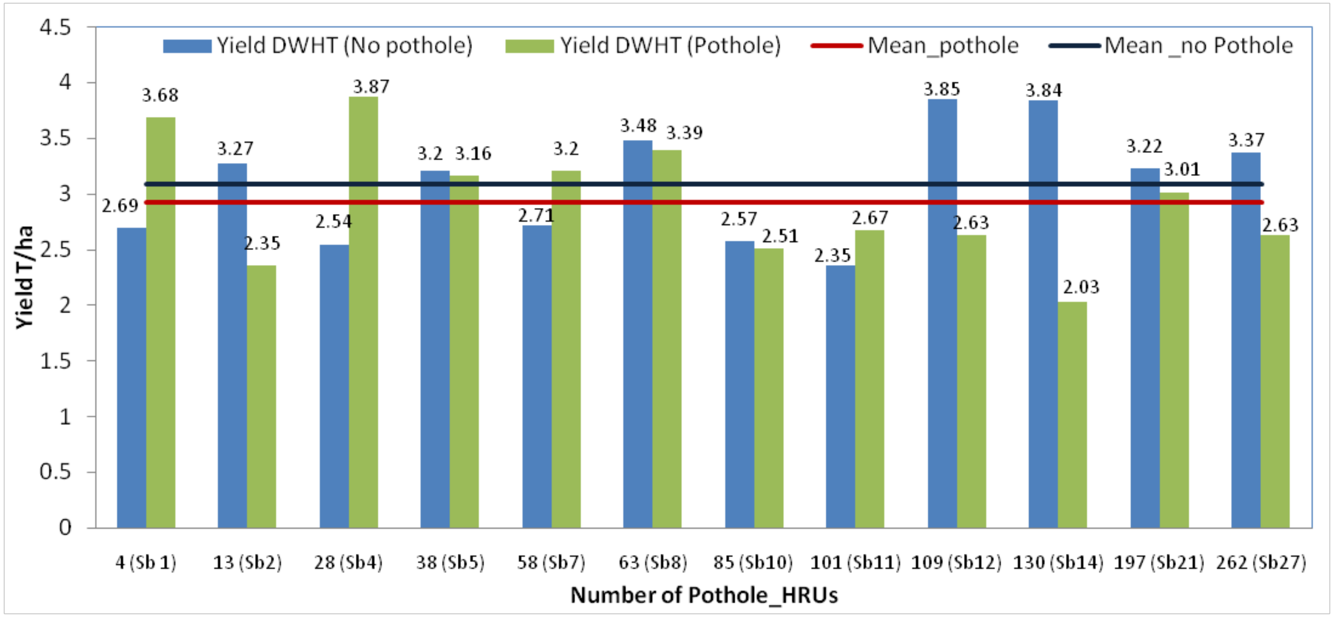
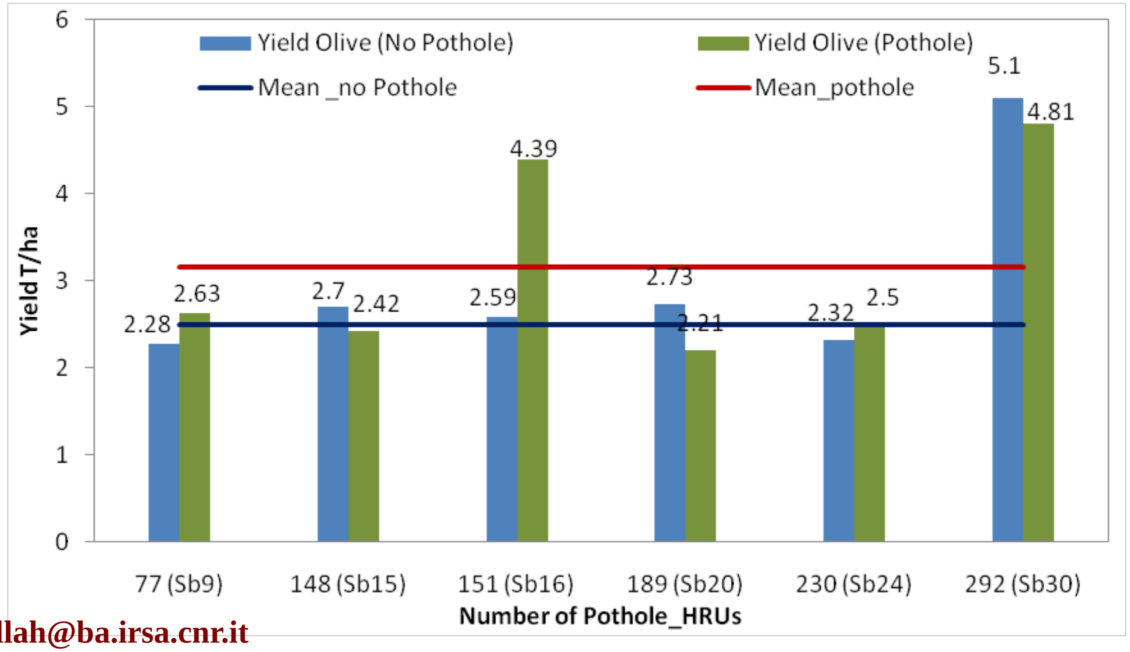
Scenario 2: Crop yield change





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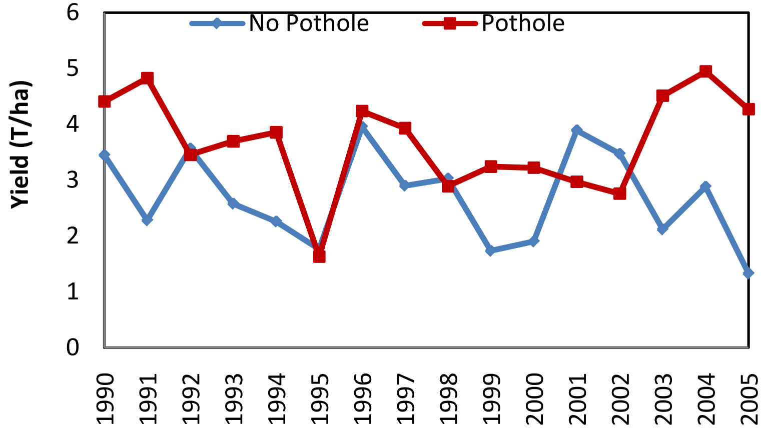
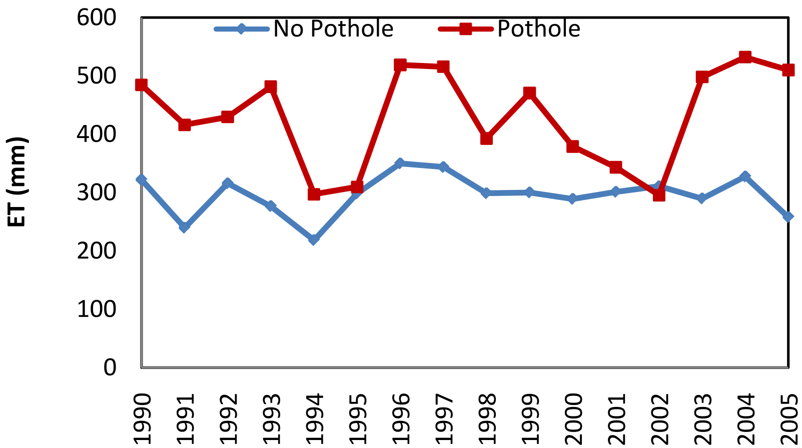
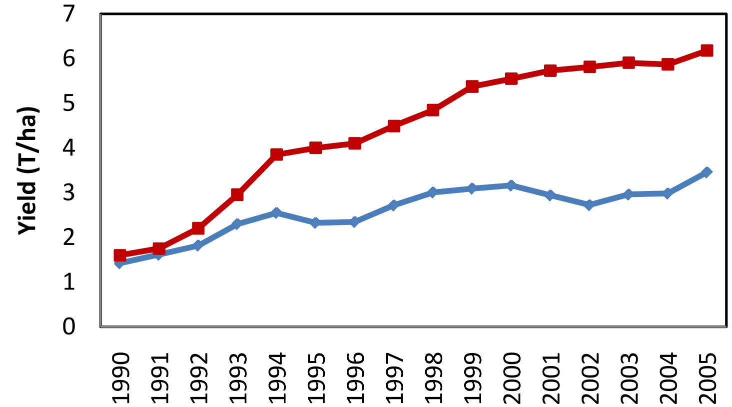
Scenario 2: without pothole

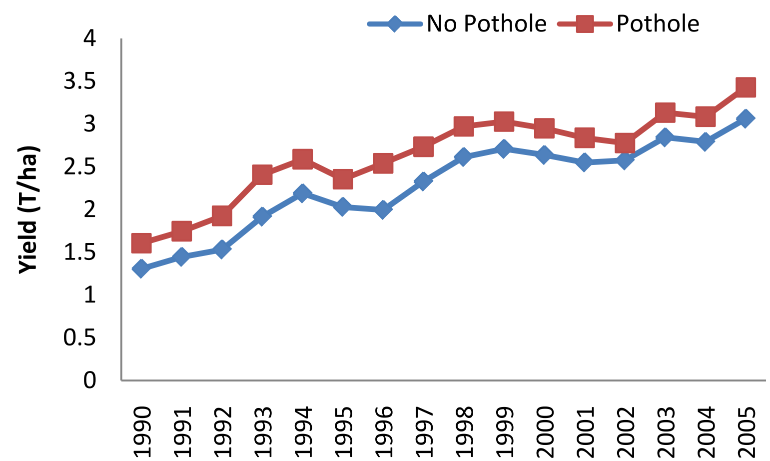
DWHT





Olive





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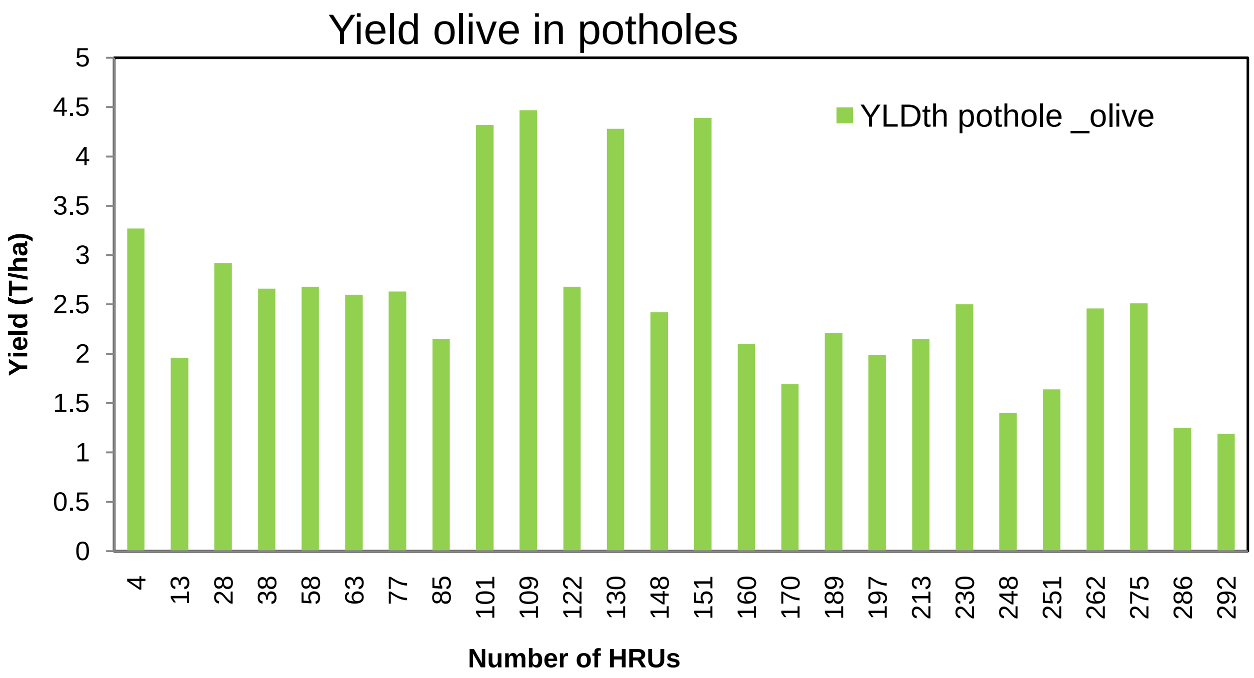
Scenario 3: Olive in potholes



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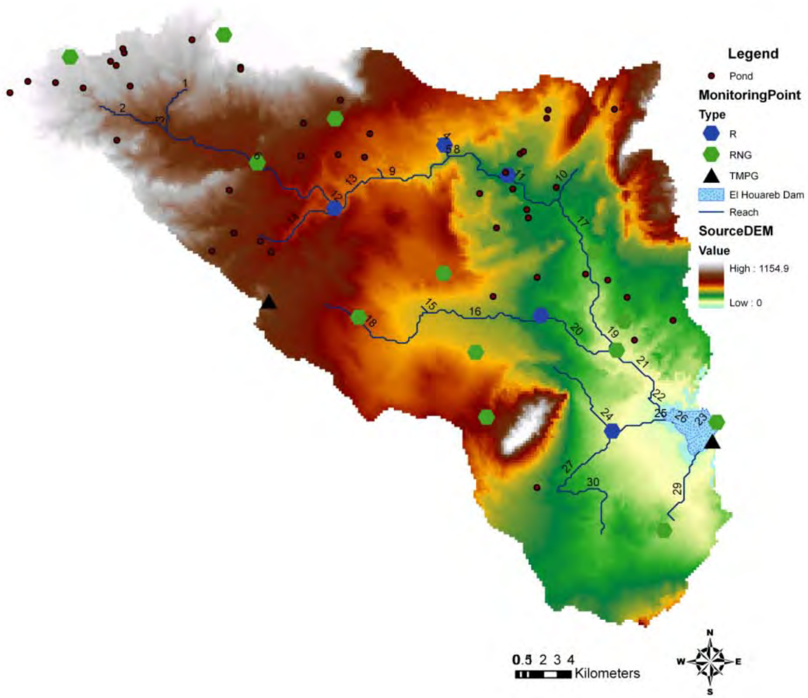
Scenario 4: Climate change



Canadian Global coupled model (CGCM3.1) version T63

Baseline
1961-2001

Future scenarios

A2

A1B

B1

Daily data
2010-2039
2070-2099

- Statistical downscaling for different stations (Precipitation & temperature)
- linear and fourth degree non-linear regression were tested.

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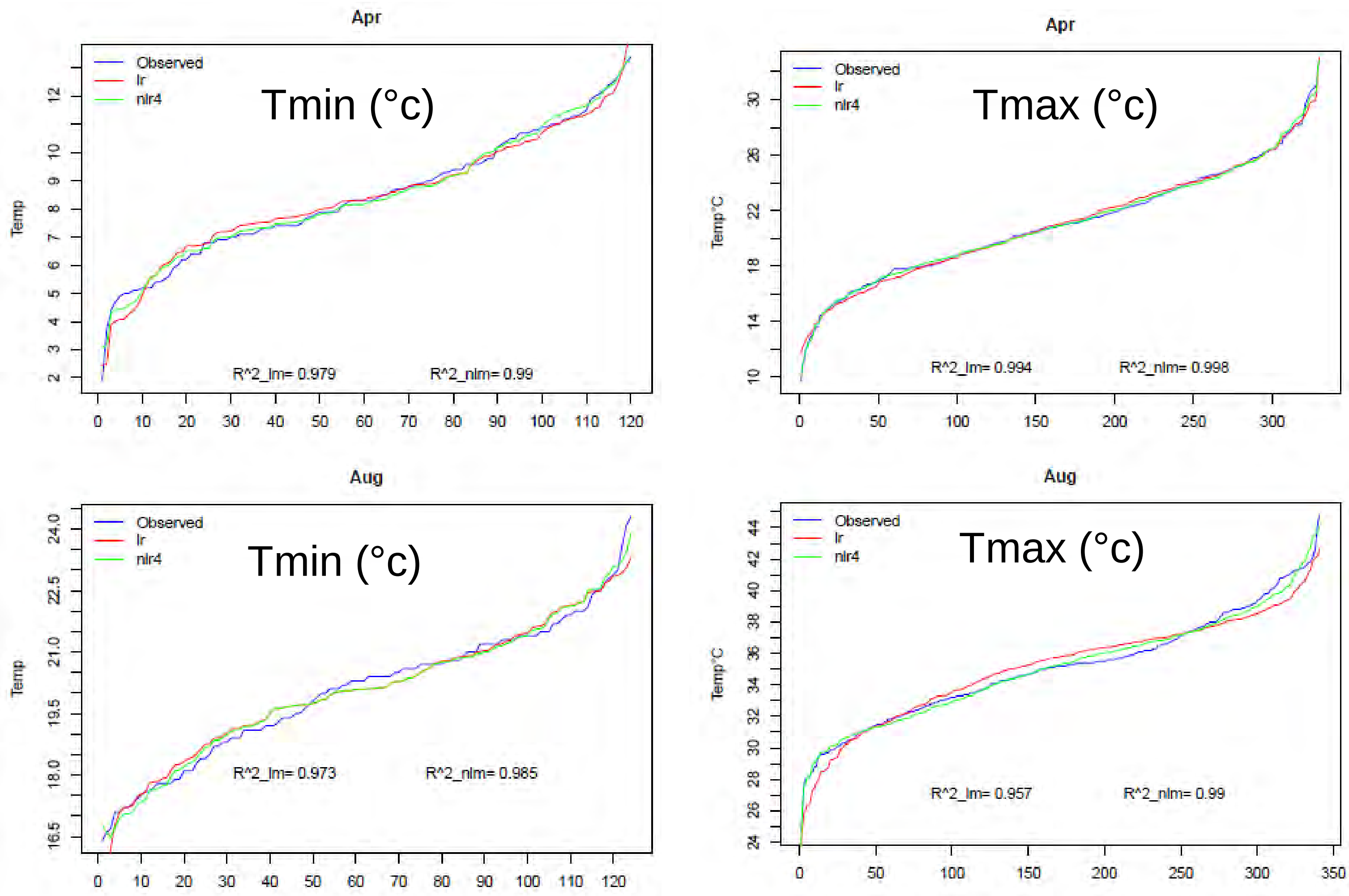
Scenario 4: Climate change

- **Calibration (1990-2000)**
- **validation (1986-1989)**



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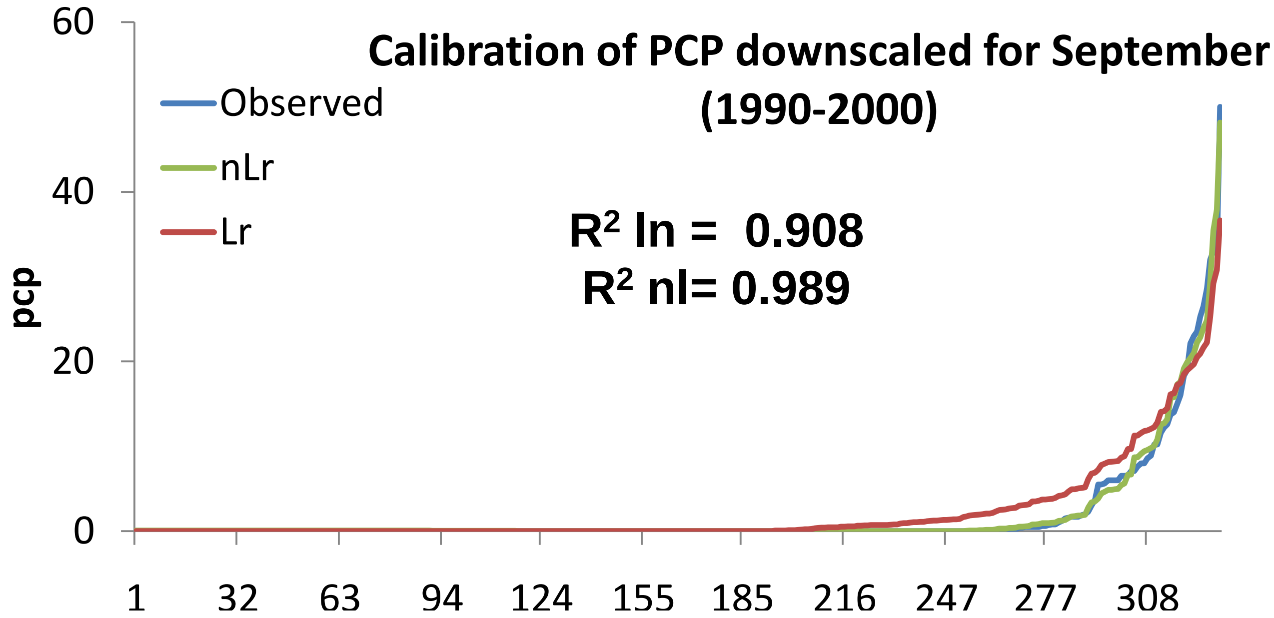
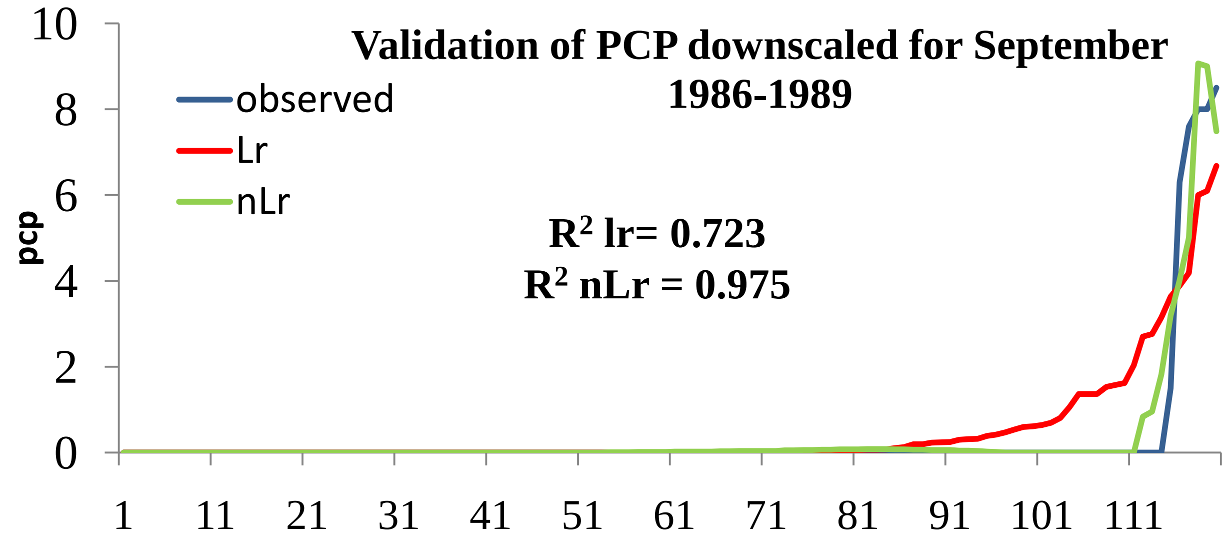
Scenario 4: Climate change





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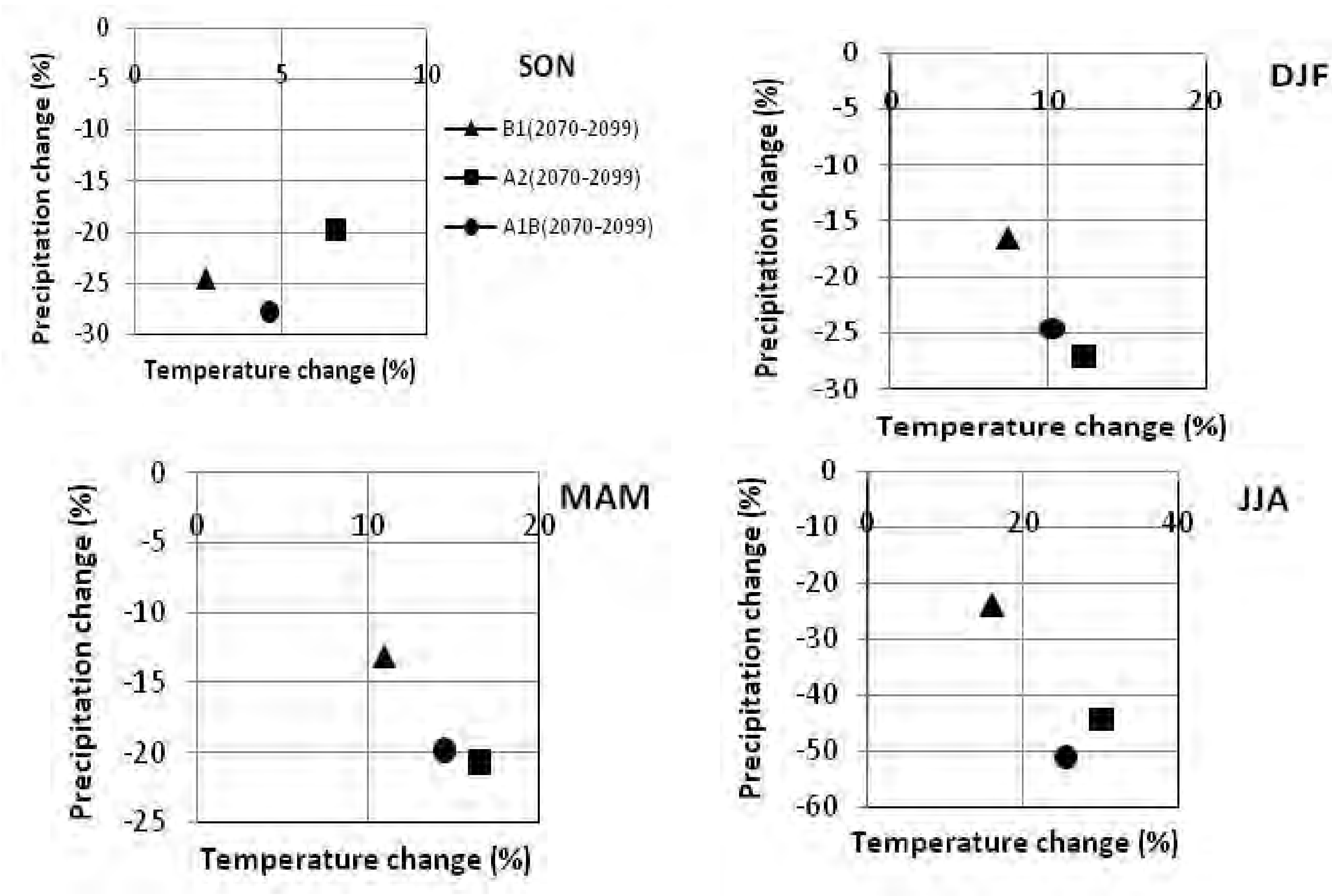
Scenario 4: Climate change



Saisonnal change in temperature and precipitation for futue predicted scenarios.

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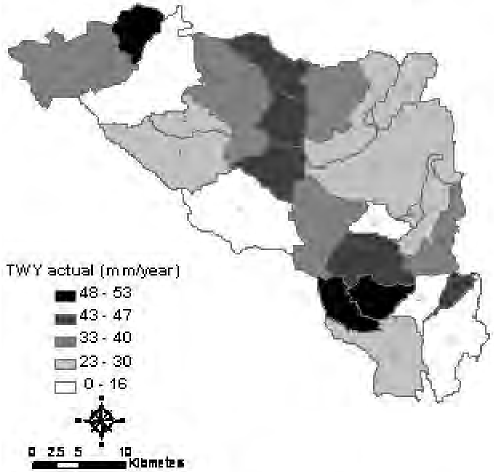
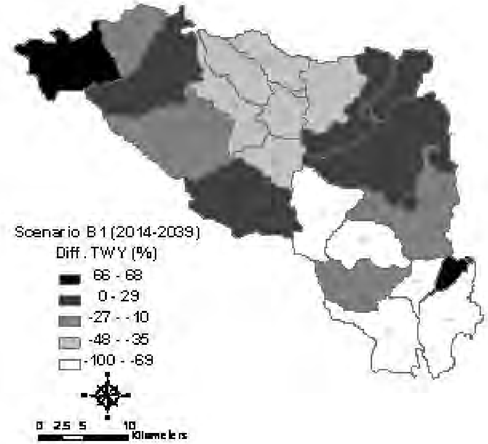
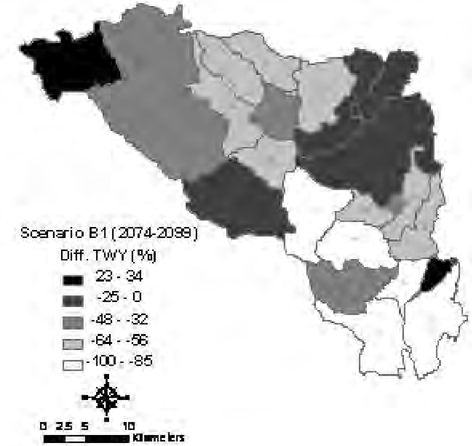
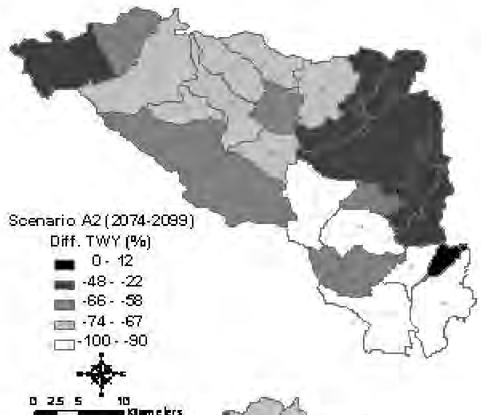
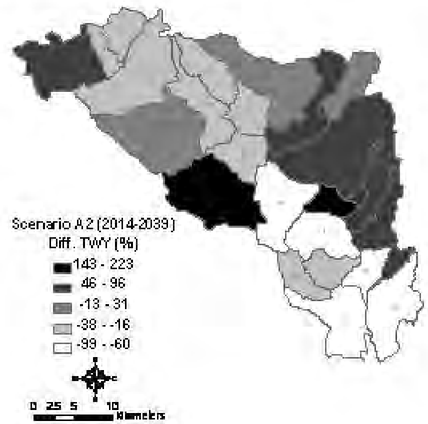
Scenario 4: Climate change

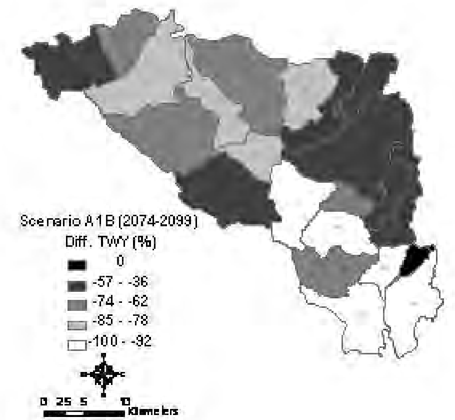


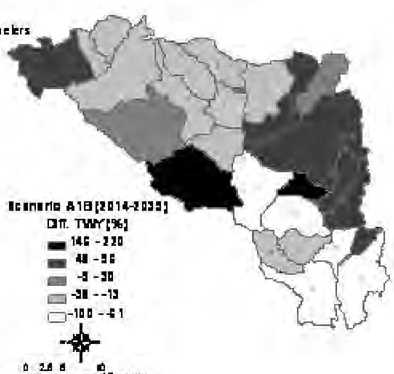












Total water yield (mm/year) during the simulation period (1986-1990) (a) and the anomaly graphs for A1B, A2 and B1 scenarios for periods 2014-2039 and 2074-2099.

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Scenario 4: Climate change

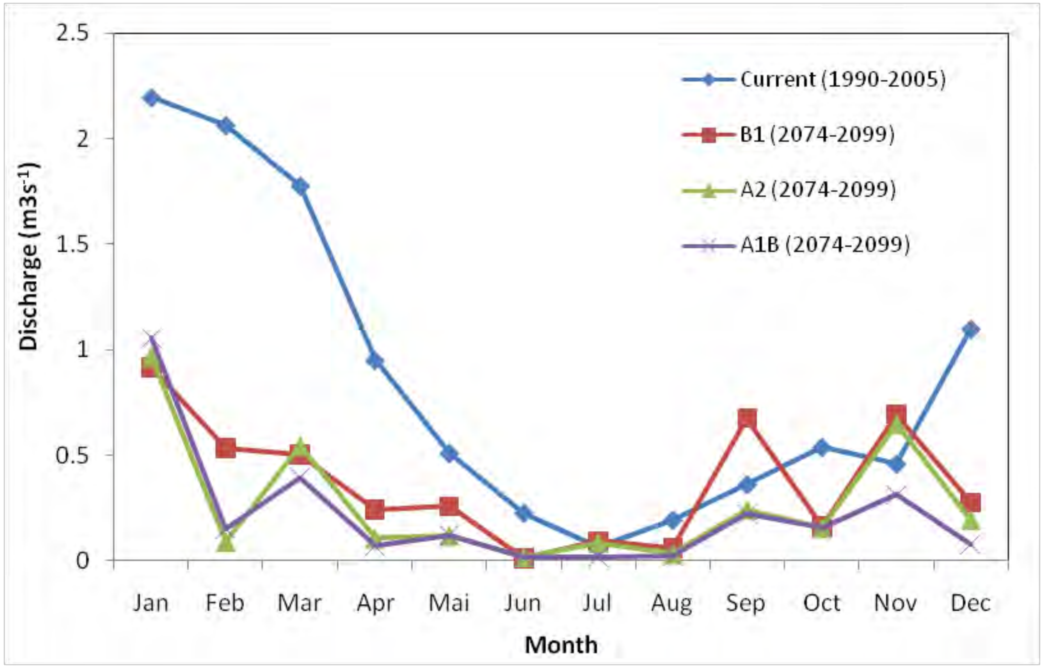

Figure 1. Mean monthly flow of the Merguellil River using simulated flows under current climate and downscaled GCM-generated stream flow.

The hydrographs under predicted climate for 2054–2099 differed markedly from the current conditions. Monthly flows decreased considerably compared to current conditions and did not exceed 1 m^3s^{-1}. Except for scenario B1 and A2 where the discharge exceeds the current mean discharges respectively for the months of, September, November and November.

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Scenario 4: Climate change

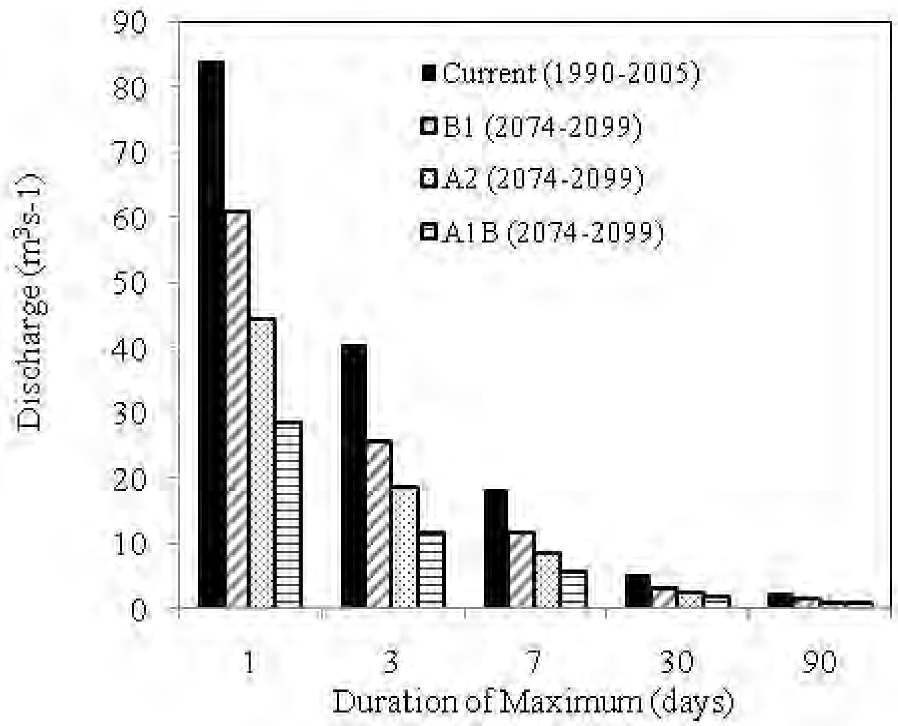

Figure. One-, 3-, 7-, 30- and 90-day maxima flows for the Merguellil River, using simulated flows under current climate and downscaled GCM-predicted stream flows.

There were significant changes in the magnitude of the 1-, 3-, 7-, 30- and 90-day maxima under predicted future climate compared to modeled current conditions. On average, the magnitude and duration of yearly floods under future climatic scenarios is expected to decrease comparing to current conditions

The flow regime under predicted future climate scenarios will have an extended period of time with zero flow (247, 241, 242 days respectively for the scenario B1, A2, A1B) compared to current conditions (173 days).

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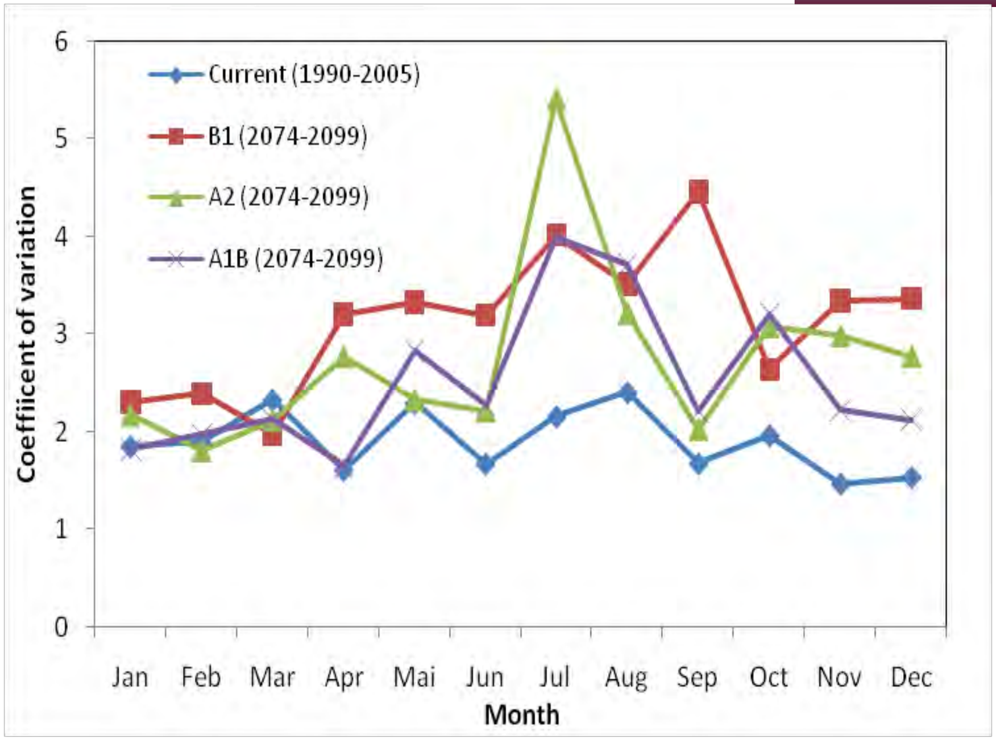
Scenario 4: Climate change



Coefficient of variation for mean monthly flow of the Merguellil River using simulated flows under current climate and downscaled GCM-generated stream flow.

For the most part of the year, the predicted future coefficient of variation was greater than the current coefficient of variation. The exception was in March where the coefficient of variation was a little bit higher under current climate.

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Conclusion

- The SWAT model was rather successful in reproducing water flow.

- Soil and water conservation works (Potholes, Reservoirs, ponds) has changed the hydrological regime within the catchment. They have an important role of the retention of sediment and water harvesting.
- The use of these reservoirs remains modest. Further studies should investigate the water management in the reservoirs in order to increase the water use efficiency.

- A better use of the fertilizer, such as not over-applying it, could substantially reduce the amount of nutrients flowing down river without compromising crop yields

- This work has shown how a modeling tool can be used to study the response of hydrology and crop productivity to change in climate factors. The Merguellil watershed's water resources are highly vulnerable to change in rainfall and temperature, which affect the hydrologic regime of the catchment .

  This climate change analysis could be very useful in strategic planning of water resources management and crop production for the future years

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