Improvement of water and energy use in sprinkler irrigation under semi-arid conditions

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Overview

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- Modernization of Irrigation
- Sprinkler irrigation: water-energy challenges
- Objectives
- Methodology
  - Evaluation of irrigation energy
  - Case studies
- Results
- Conclusion & Recommendations

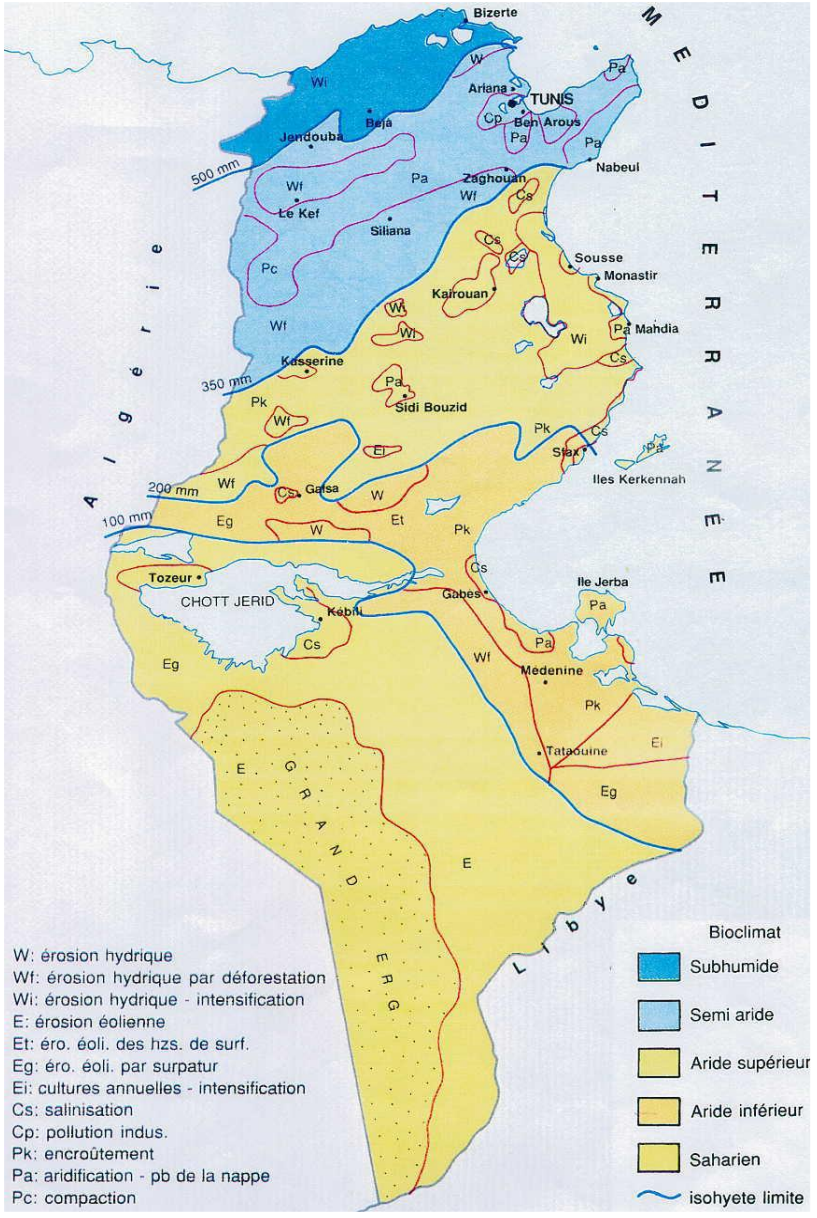
Irrigated agriculture in Tunisia

Mediterranean climate

- Rainfall :
  - north: 500-1000 mm/year
  - center: 200-400 mm/year
  - south: less then 100 mm/year
- Vulnerability to climate change + recurrence of droughts periods

Limited water resources

- 385 m^3/year per capita
- Surface water : 2,7 km^3
- Underground water: 2,1 km^3
- Nonconventional water: 0,240 km^3



Irrigated agriculture in Tunisia

- Irrigated area of 450 000 ha (intensive)
  - 7% of the arable land
  - 36 % of total agriculture production
  - 27% of the workforce
  - 90% of vegetable production

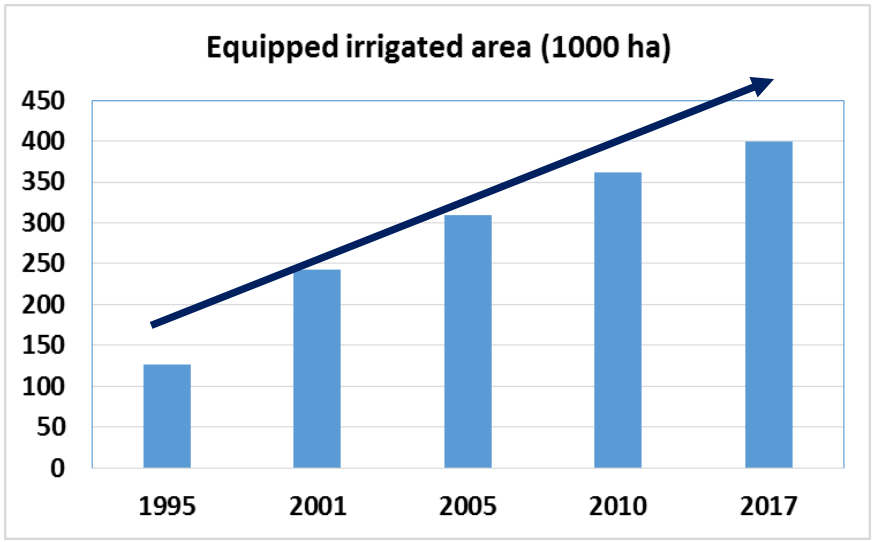
- **Irrigation** consumes 2,08 km^3/year ≈ **80% of the water resources**

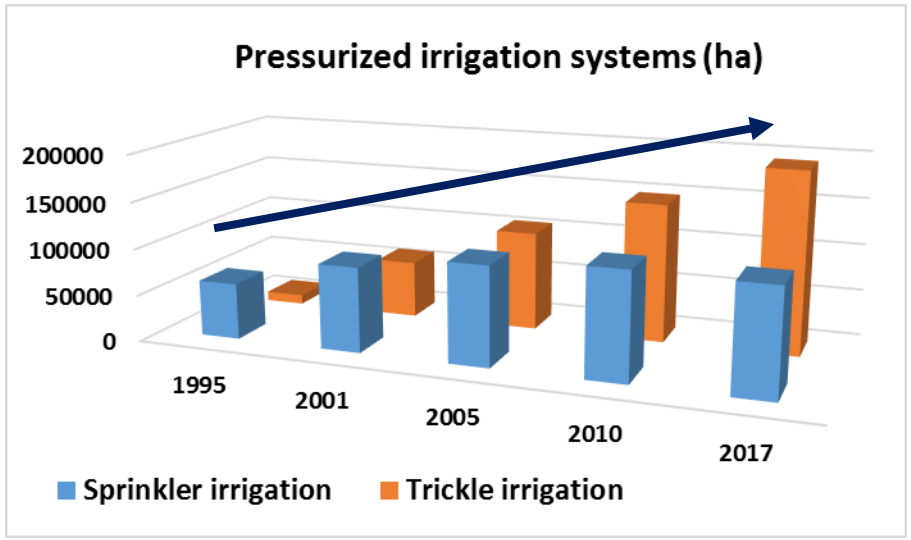
- ↗ Mobilization of water resources
- ↗ Water demand for irrigation
- ↗ Irrigated acreage

} **Adoption of irrigation water saving technologies**

Modernization of Irrigation

- National program for water conservation: improve irrigation efficiency



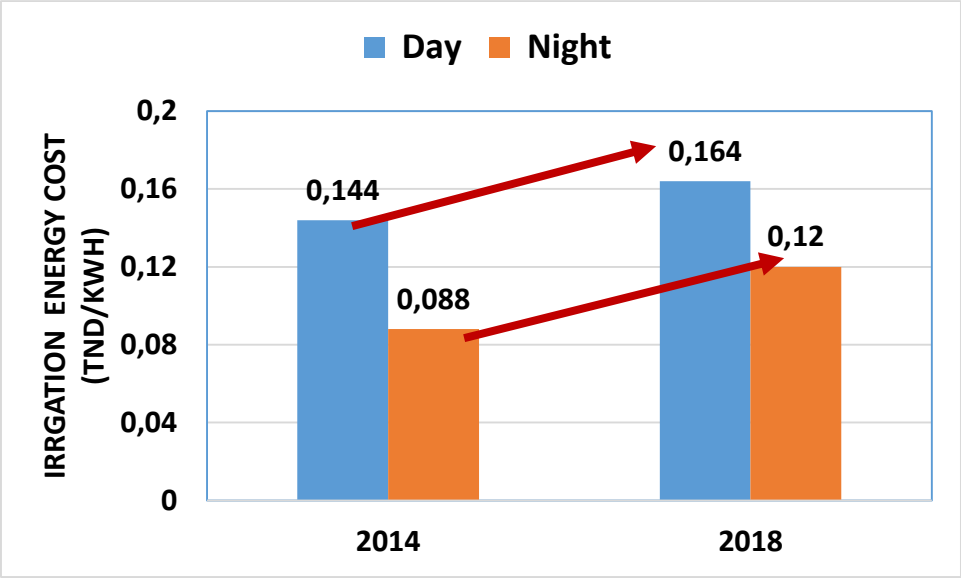


- Switching from surface to pressurized networks : additional costs of investment, pumping and maintenance

- Efficient management of energy resources : major concern to face increase in energy demand for irrigation

Sprinkler irrigation: water-energy challenges

- Sprinkler systems acreage: 114000 ha, 28.3% total irrigated area
- **Economic dilemma:** selection of the optimal depth to avoid:
  - **under irrigation** (yield decrease, soil salinization)
  - **over irrigation** (water, yield and fertilizer losses, **increase pumping costs**)
- Limited research studies on water-energy nexus
- Increase of energy costs for irrigation



(1TND≈0,33 USD)

Objectives

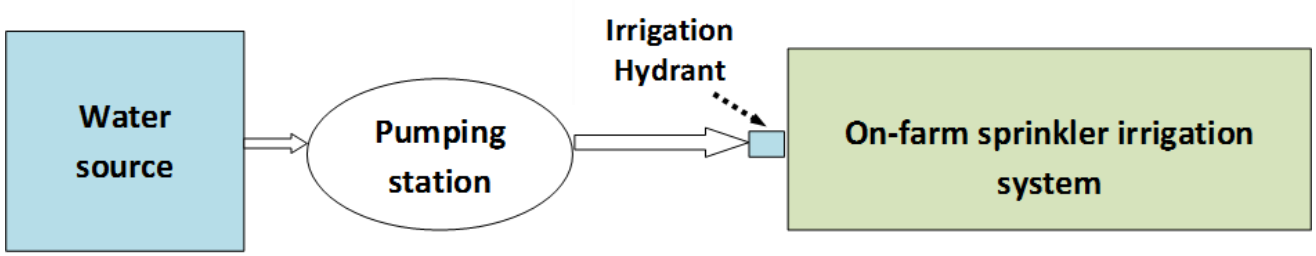
- characterize and evaluate the energy requirements of sprinkler irrigation systems

- investigate the impact of irrigation performance on energy consumption of sprinkler irrigation systems

Methodology

Evaluation of useful energy for irrigation: E (kWh)

E = Water supply energy (E_1) + Water distribution energy (E_2)



$$E_1 = \frac{C\,V_d\,H_m}{\eta\,E_t} \qquad E_2 = \frac{C\,V_c\,H_d}{E_a}$$

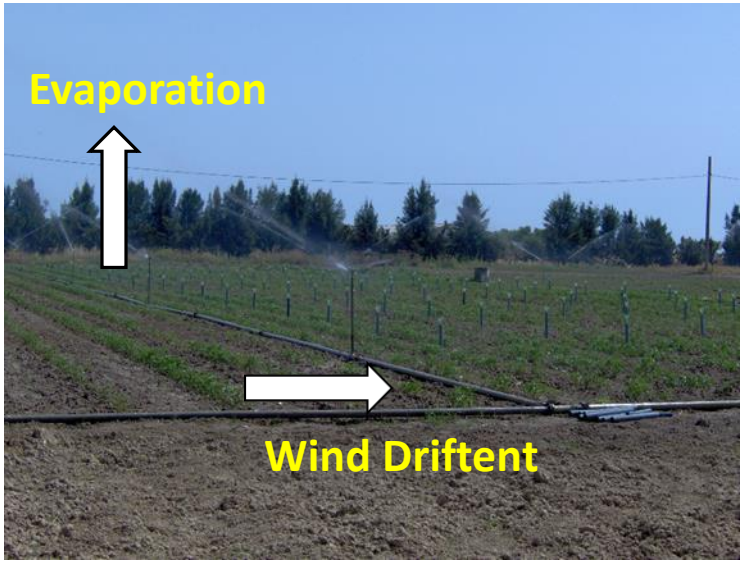
- V_d: amount of irrigation water (m^3)
- V_c: water available to the crop (m^3)
- E_t : water supply efficiency (%),
- E_a : application efficiency (%), $E_a = 100\ (V_c/V_d)$
- η : pumping efficiency (dimensionless)

Methodology

Case studies

Explore the impact of irrigation performances on the water distribution energy (E_2)

Potato crop



Tomato crop

Performance indicator parameters

Application efficiency, $E_a = 100\ (V_c/V_d)$

Wind Drift and Evaporation Losses (%)

Results

Impact of application efficiency on water distributed energy

Potato crop

Treatment	V_d (m^3/ha)	Hd (m)	E_a (%)	E_2 (kWh/ha)
T_0	3200	36	81	314
T_1	4300	36	69	422

- The low value of E_a with T_1 stems from the percolation losses estimated at 57 mm/yr
- Reduction in E_a from 81 to 69 % induces a substantial increase (34.4 %) of water distribution energy

Results

- **Impact of application efficiency on distribution energy cost**

Potato crop

Treatment	Yield (T/ha)	Distribution energy cost (TND/ha)	Energetic cost (kWh/T)	Water use efficiency (Kg/m^3)
T_0	46.2	**40.1**	6.8	**14.4**
T_1	50.7	**53.9**	8.3	**11.8**

- Energy distribution cost depends on the volume of applied water on the soil surface

- Reduction in E_a generates a relative increase of 22.4 % in the energy cost (kWh per ton) as well as a relative decrease of 18 % in the WUE

Results

Tomato crop

Irrigation performances

	Day time	Night time
V_c (m^3/ha)	5490	6417
E_a (%)	74.1	86.6
WDEL (%)	24	7
H_d (m)	35	35

- Night time improve irrigation performances:
  - Increase of application efficiency
  - Significant decrease in WDEL
  - Fair distribution of water

Results

Tomato crop

Distribution energy cost

Irrigation time	Relative Yield Loss (%)	Distribution energy cost (TND/ha)	Energetic cost (kWh/T)
Day	11	90.2	14.4
Night	3	69.6	12.0

- By night time, energy cost was reduced by 22.8% although seasonal applied water was larger than for day time

- Adoption of night irrigation reduces the energy cost expressed in kWh/T by 16.4% compared with day time

Conclusion & Recommendations

- Energy and water saving can be achieved by :
  - improving irrigation efficiency
  - adopting proper irrigation management strategies: Night irrigation scenario

- Notwithstanding the changing from surface to pressurized systems (sprinkler), a saving of about 25% on the energy consumption can be achieved

- Under the arid and semi-arid local conditions, further investigations on technical and socio-economic implications of irrigation modernization need to be assessed at a larger scale (irrigation district) in order to improve water and energy efficiency

Credits and Acknowledgements

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Thank you for your Attention