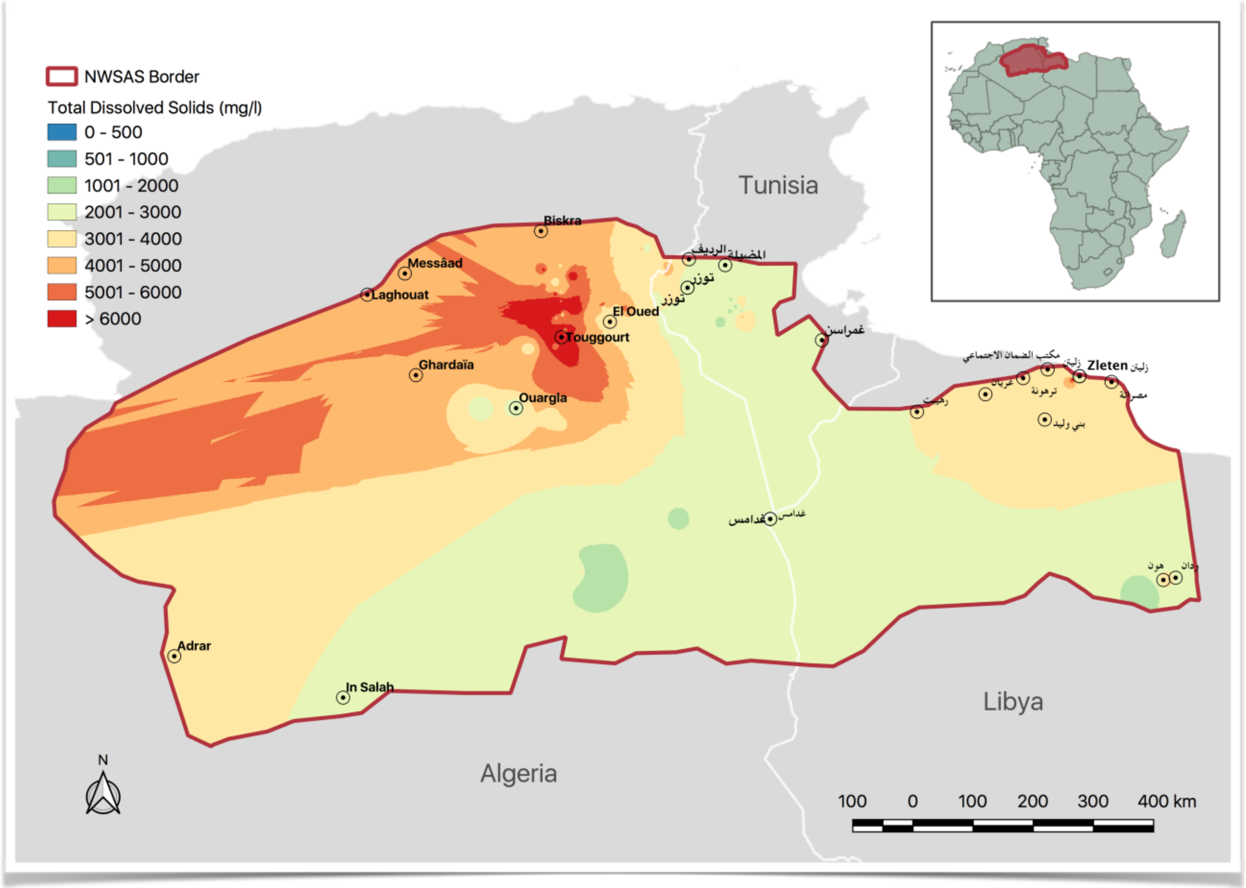

ASSESSING THE WATER-FOOD-ENERGY-ECOSYSTEMS NEXUS IN THE NORTH-WESTERN SAHARA AQUIFER SYSTEM: LEAST-COST OPTIMIZATION MODELLING OF ENERGY SOURCES FOR WATER MANAGEMENT NEEDS

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THE NORTH WESTERN SAHARA AQUIFER SYSTEM (NWSAS)

BACKGROUND

The NWSAS consists of:

1) The Continental Intercalary (CI):

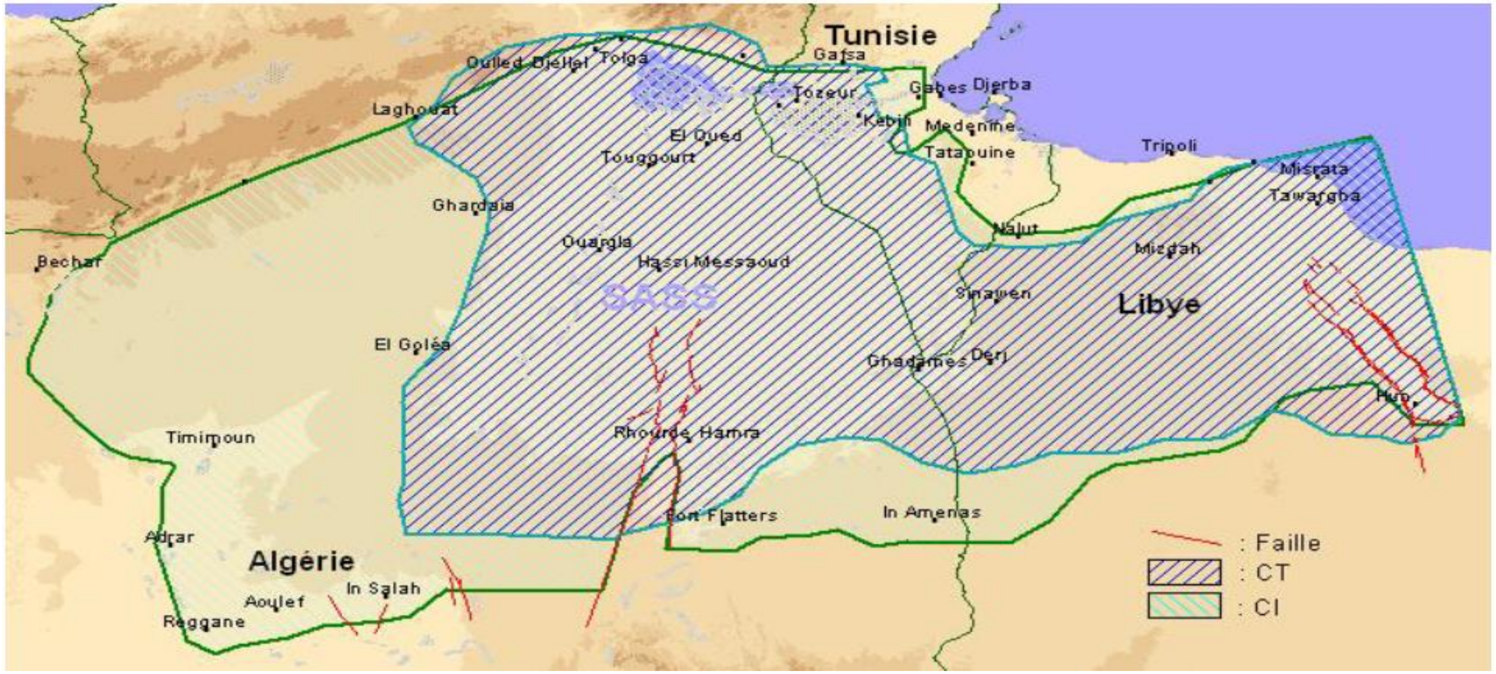
a surface area of 1000,000 km²

depth 1500 – 2800 m

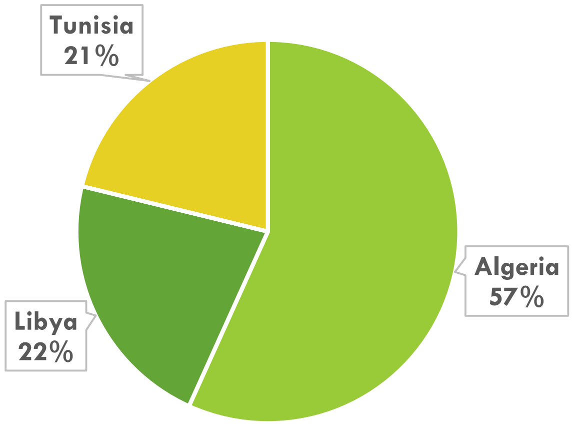
2) The Terminal Complex (TC):

area of 600,000 km²

depth of 100 – 600 m

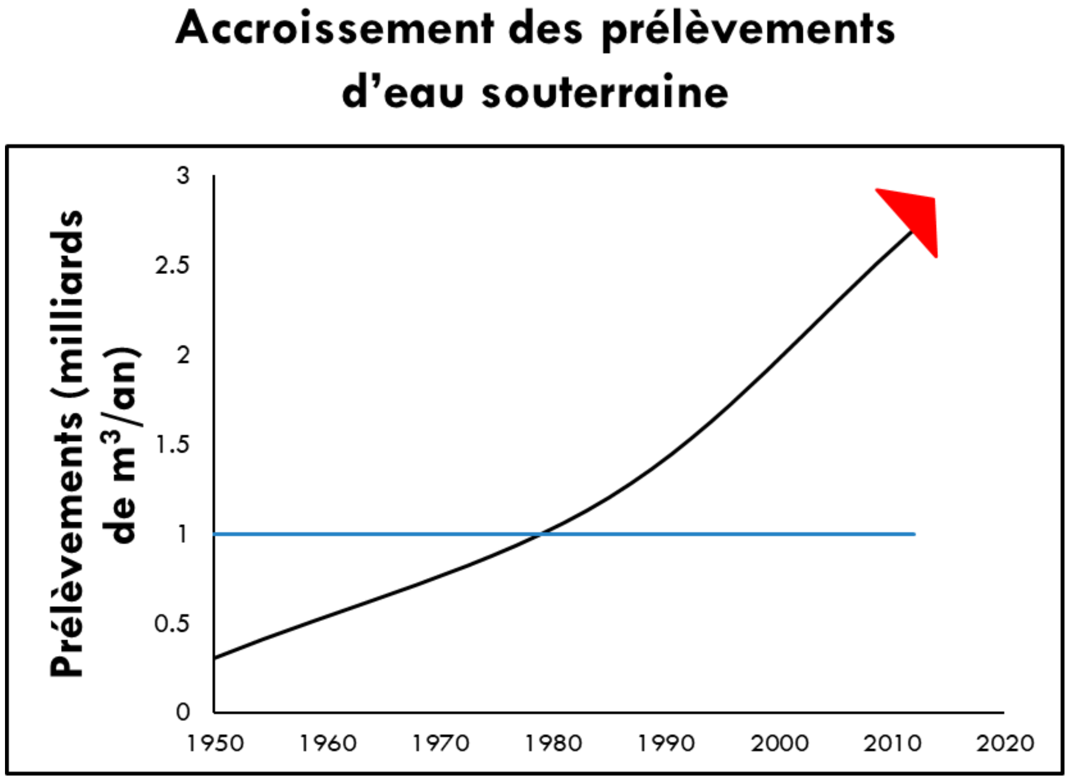


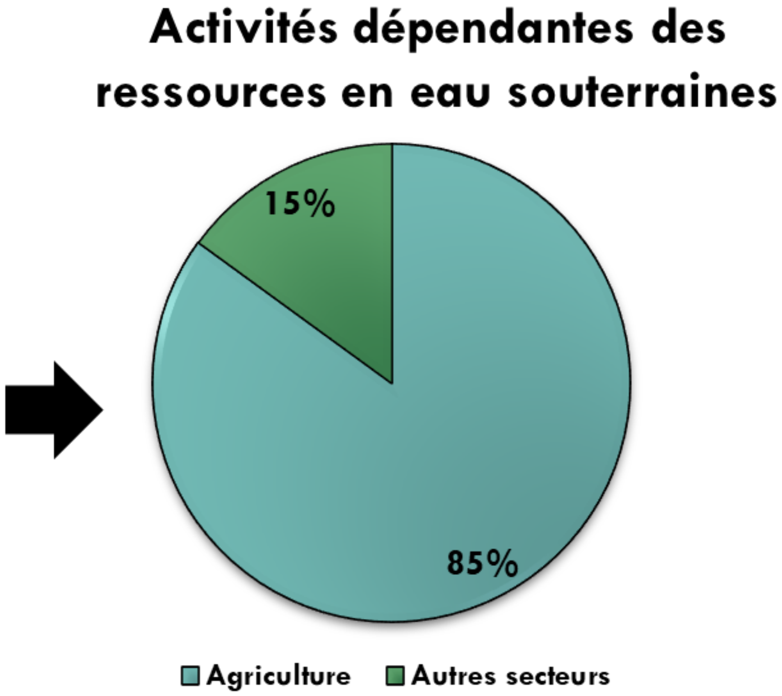
Population in the NWSAS (2014)



	Algeria	Tunisia	Libya
Country area (km²)	2,381,741	163,610	1,759,540
Country area in the basin (km²)	700,000	80,000	250,000
Share of national territory in the NWSAS (%)	29	49	14
Share of NWSAS (%)	68	8	24

PRESSURE: INCREASED GROUNDWATER DEMAND

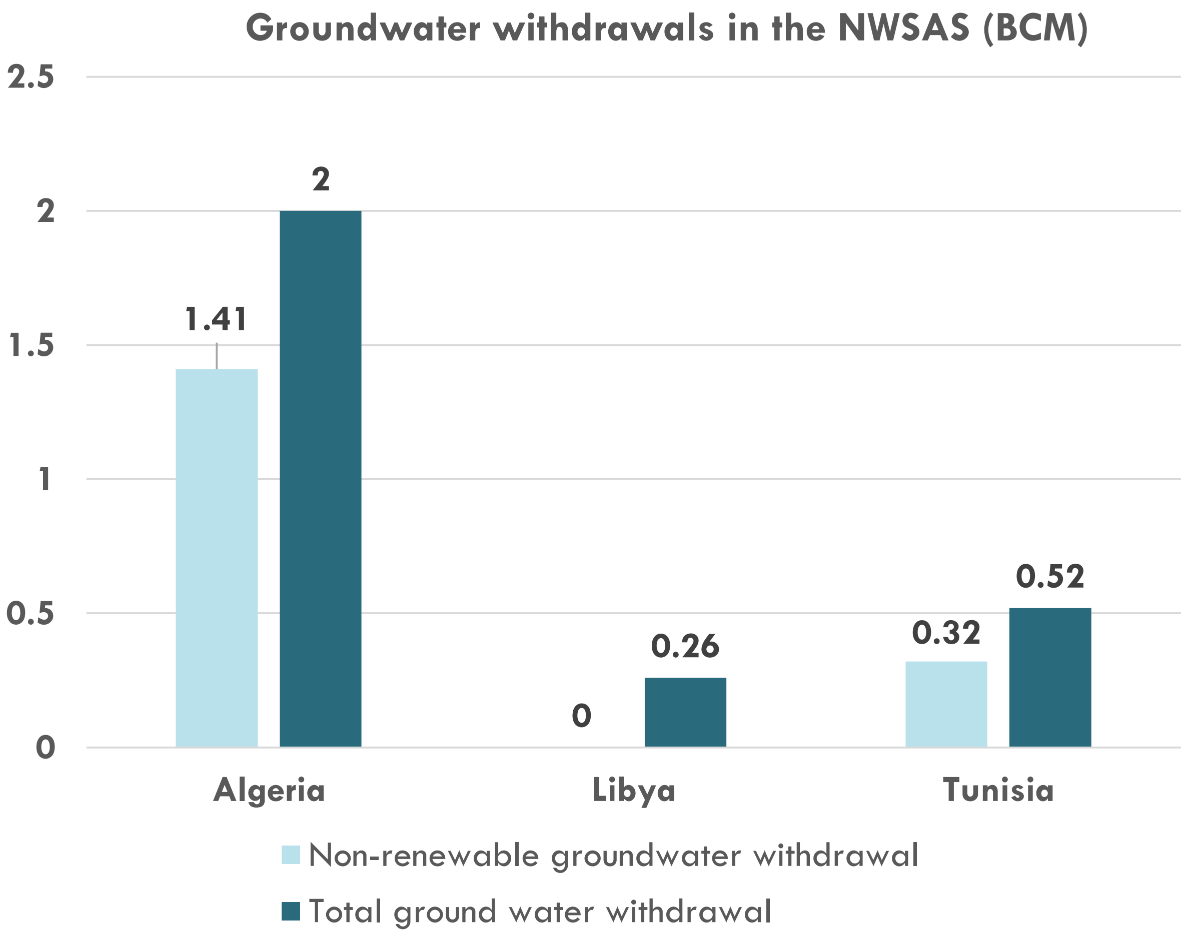




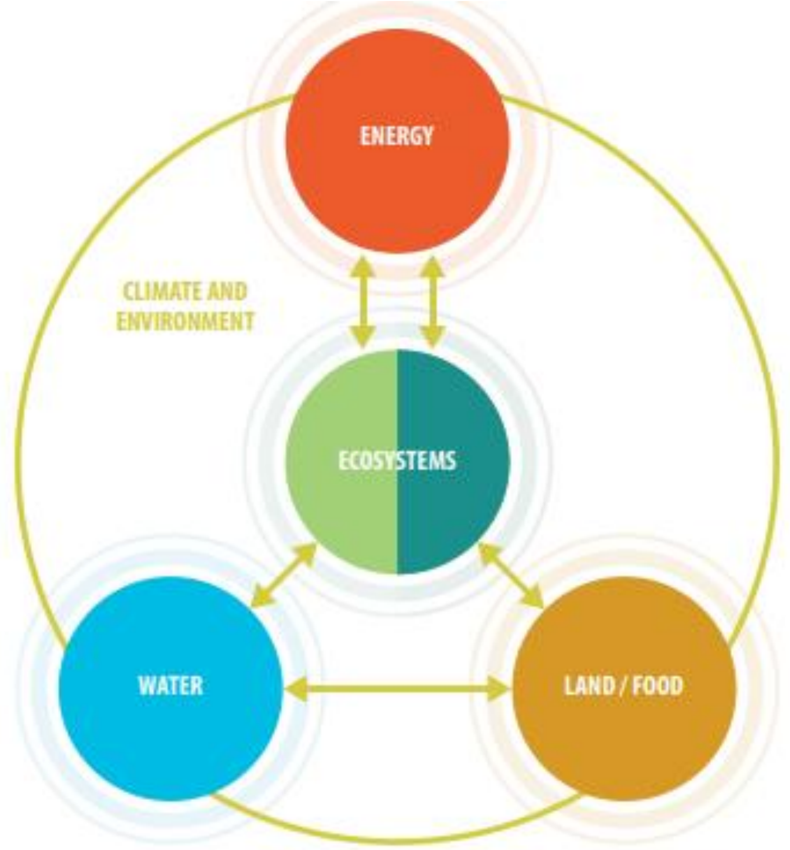
BACKGROUND

Selected Nexus challenges:

- Heavy exploitation of the NWSAS;
- Reduced piezometric head/Loss of artesian pressure/Lower water table;
- Excessive pumping (energy) demand.
- Others…



A NEXUS APPROACH TO TACKLE GROUNDWATER RELATED CHALLENGES IN THE NWSAS



Challenges are interlinked -> this *requires* coordinated action (across sectors and countries)

Intersectoral synergies can maximize impact of policy, action, and investments -> this *motivates* nexus dialogue

The "Nexus Approach" - three guiding principles (Hoff, 2011):

- investing to sustain ecosystem services
- creating more with less
- accelerating access, integrating the poorest

Approach increasingly adopted by international organizations, refined by analysts/modellers, tested in policy making

Experience in the MENA region: the "*WEF security nexus*" focus on efficiency of resources and strategic planning

THE PROCESS

- Nexus issues
- Nexus solutions
- Conclusions and recommendations

- Financed by SIDA
- Supported by the Global Water Partnership Mediterranean, Water Convention/UNECE, Sahara and Sahel Observatory (OSS)
- Consultation Mechanism of the NWSAS (intergovernmental) provides the framework
- Uses the methodology and experience about assessing nexus issues from a series of transboundary assessments under the Water Convention

	Water	Energy	Agriculture	Environment
Governance & international cooperation	1. Enhance **local water management** including by: revitalising **participatory** models in oasis and enhancing the enforcement of **existing laws** on water. 2. Reinforce **transboundary cooperation** for sustainable groundwater resource management.	6. Enhance mechanisms for the **coordination of energy development with other sectoral plans**, to anticipate tradeoffs and build on intersectoral synergies.	9. **Set up agricultural policies** oriented toward **reasonable, sustainable and productive agriculture.** 10. **Valorize local products** and strengthen programs for a more **balanced diet** while involving **young people and women** in economic and social development of the oases.	13. Increase **awareness of the trade-offs and synergies** between different sectors in public institutions.
Economic & Policy Instruments	3. Set up dedicated **policies and related incentives** for **wastewater reuse** in agriculture and urban areas. 4. Strengthening **water demand management**, including through water saving programs.	7. Develop a sustainable program for diversified, **multi-purpose renewable energy** and the **sustainable upscale of small-scale solar irrigation.**	11. Promote the **circular economy** including **agroecological practices,** by means of ad-hoc **economic measures and social instrument**.	14. Upgrade **inter-sectoral cooperation** based on a detailed **water balance of the aquifer** that includes sectoral demands as well as environmental needs.
Infrastructure & Innovation	5. Upscale the use of **non-conventional water resources** through desalination and wastewater treatment.	8. Improve the reliability of the **electricity grid in the rural area,** thereby enhancing the integration of renewables for remote and multiple uses.	12. Enhance **innovative practices and techniques for sustainable soil and crop management** and invest in their upscaling and dissemination.	15. Systematize **environmental and social impact assessment** for all new **infrastructure** (large and small scale).

Synergy e.g.

Agricultural activity

- What is the total irrigated area in the region?

Water demand

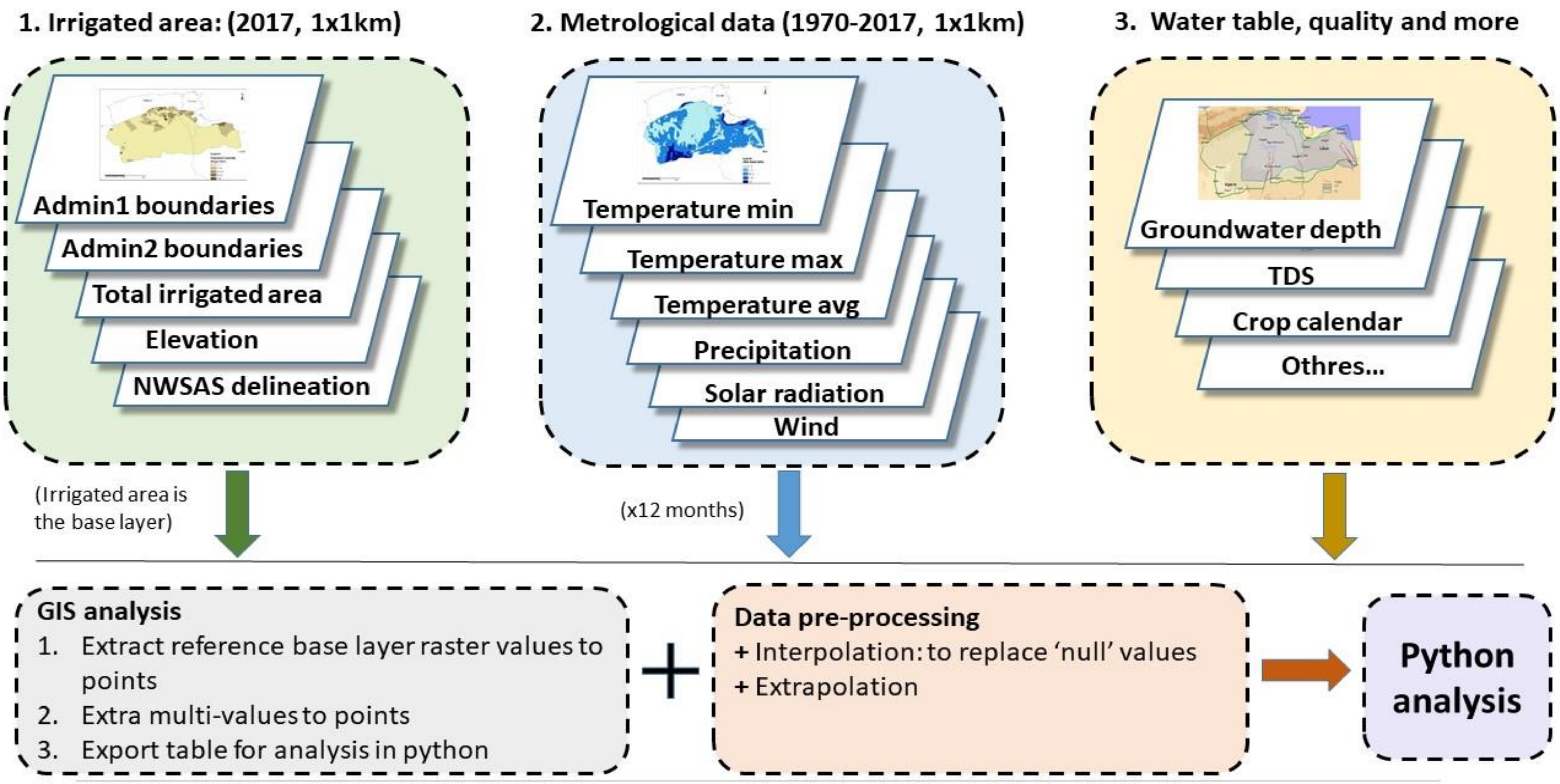
- What is the total water demand for irrigation?
- What is the impact of improving irrigation systems?

Electricity demand

- How much energy required for pumping?
- If desalination would be needed, how much energy would be required?

Electricity Supply

- What is the least cost electricity supply option?
- What makes PV more competitive in the region?



Approach: *To develop an open source GIS-based model that informs integrated planning in the NWSAS.*

NECESSARY TO VALIDATE THE DATA: CROPLAND CALIBRATION

Data product selected for determining the extent of irrigated area: European Spatial Agency's (ESA) Climate Change Initiative (CCI) land cover S2 prototype for Africa dataset (ESA, 2016) - a fine spatial resolution throughout the entire NWSAS region.

- Using ESA CCI, the total cropland area in the NWSAS estimated at 860,000 ha >> national statistics indicate only about 270,000 ha of irrigated land (using NWSAS groundwater)

Consultation with local stakeholders -> identification of the sources of classification error in ESA CCI map -> development of a calibration methodology to eliminate the misclassification errors and identify croplands using groundwater, based on a Multi-Criteria Decision Analysis (MCDA)

- (potential) sources of misclassification in the ESA CCI identified: sparse vegetation, rain-fed crops, irrigated crops using surface water and irrigated crops using water from external sources (in relation to NWSAS) such as nearby dams.

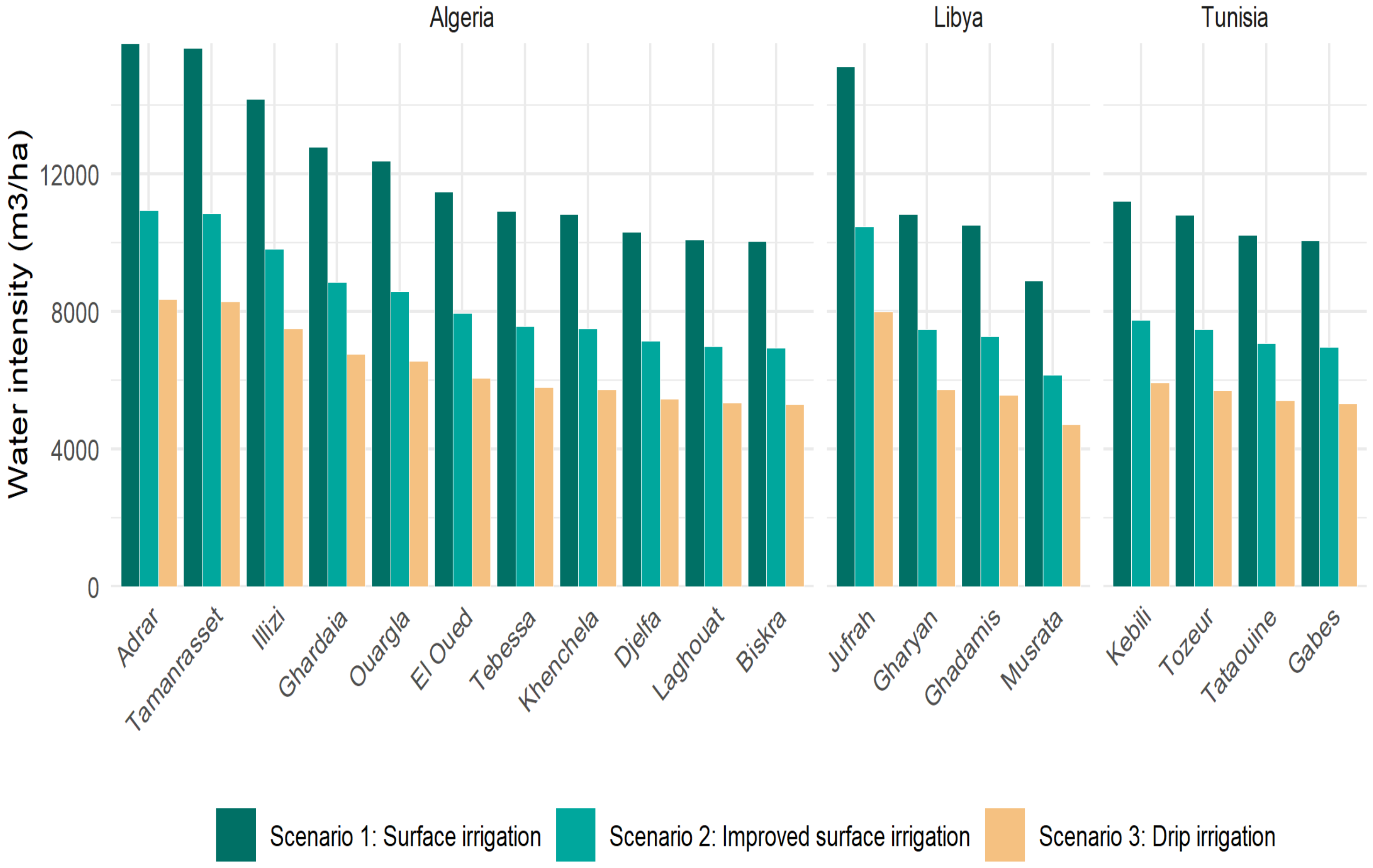
SELECTED RESULTS – IRRIGATION WATER DEMAND

- Investment in improving irrigation efficiency can lead to 47% saving in water demand.

- In terms of volume can save on average 5500 m3/ha.

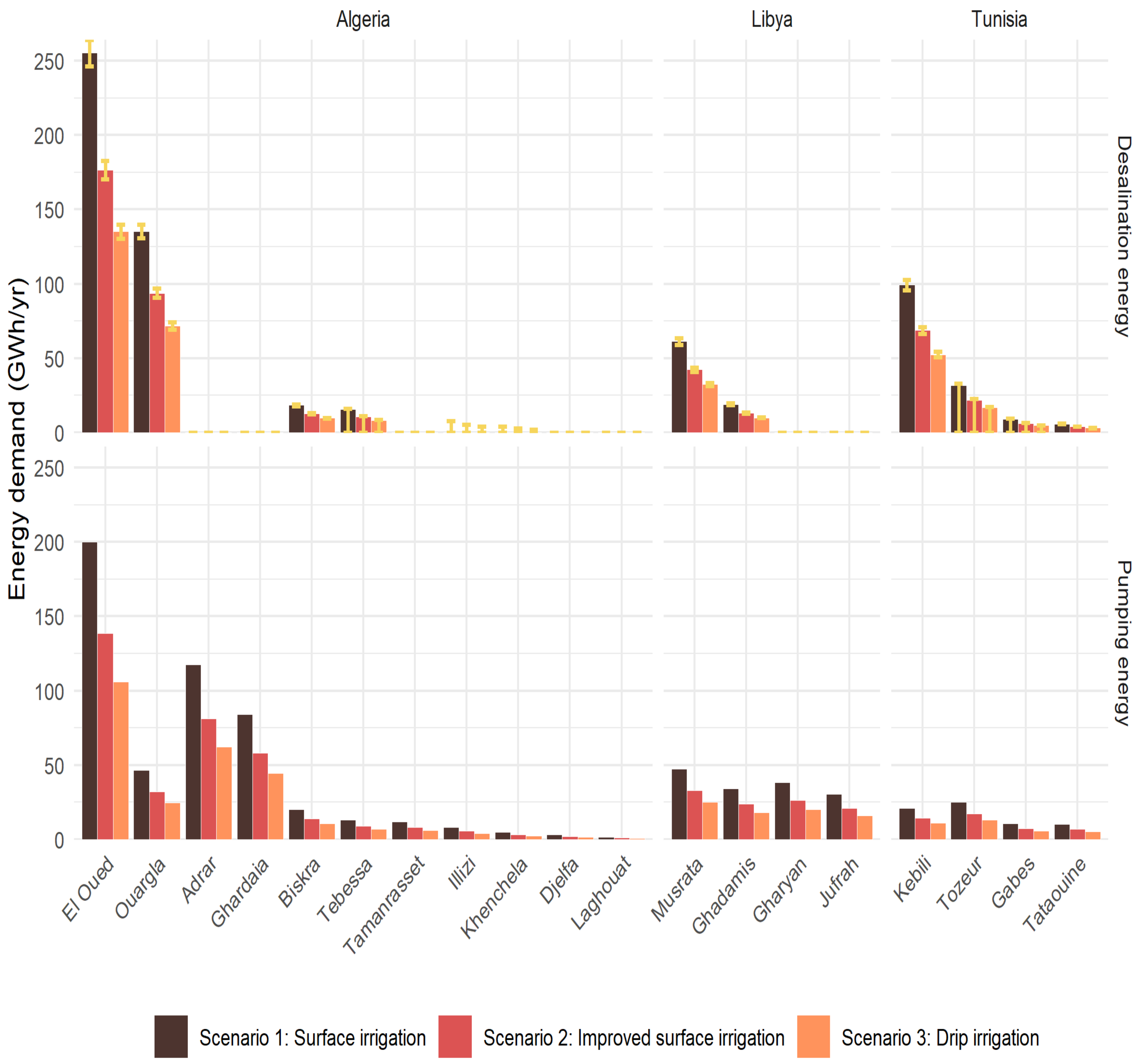
- NOTE!!:

Water efficiency does not equal water conservation!!



SELECTED RESULTS – ENERGY DEMAND

- The energy demand for pumping groundwater is about 730 GWh annually. (Algeria accounts for 70%).
- The Total Dissolved Solid (TDS) levels were studied (2000, 2500 and 3000).
- Tolerating higher TDS level (from 2000 to 3000) reduces energy demand for desalination from ca. 685 GWh/yr, to ca. 574 GWh/yr (**16% Savings**).

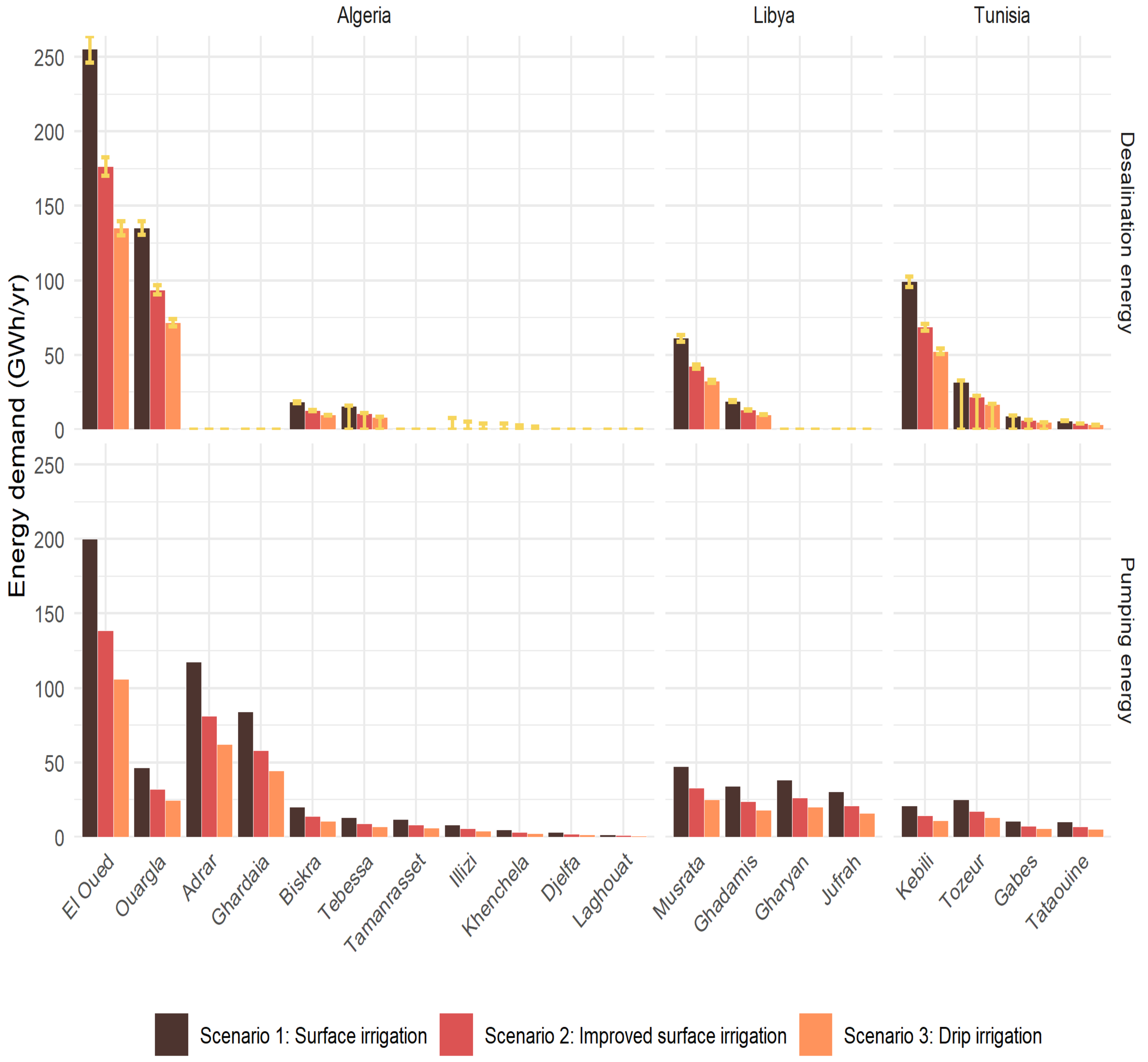


SELECTED RESULTS – ENERGY DEMAND

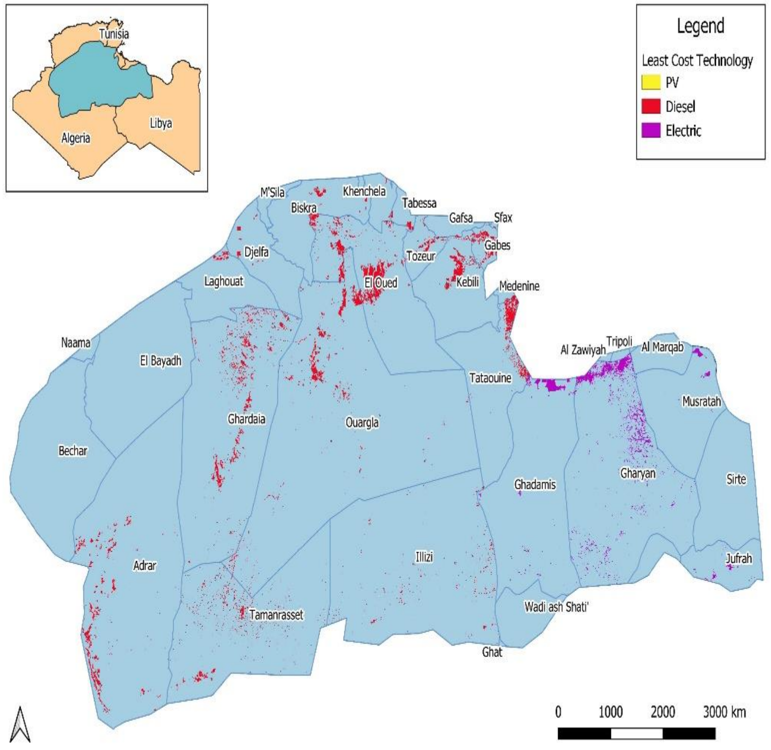
What messages we get from this:

Improving the irrigation system reduces both energy and water demand.

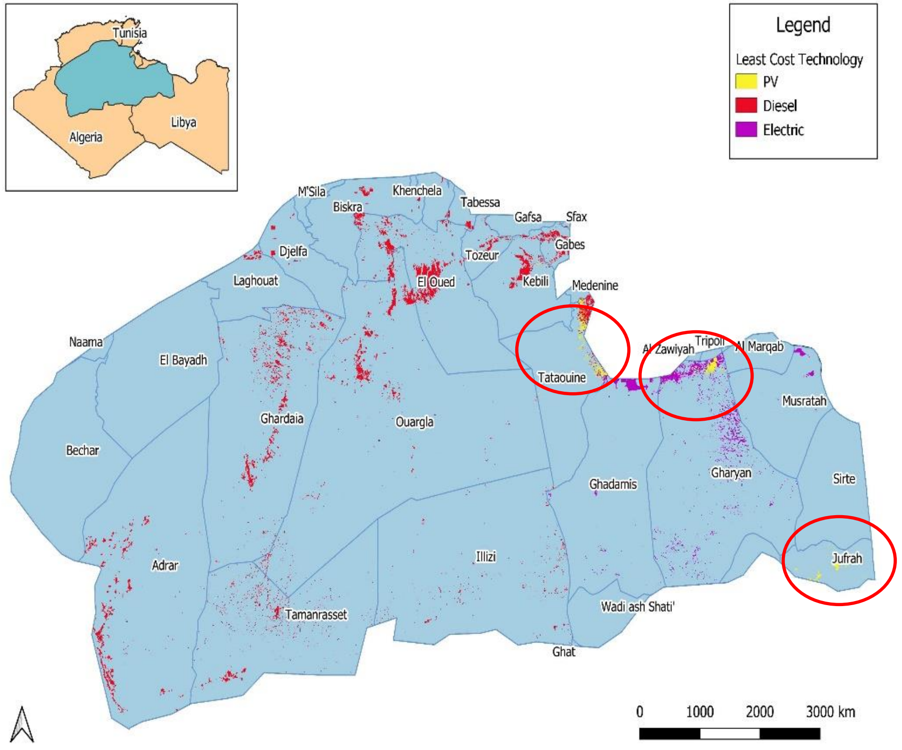
Salt resistance crops reduce the energy requirement for desalination.



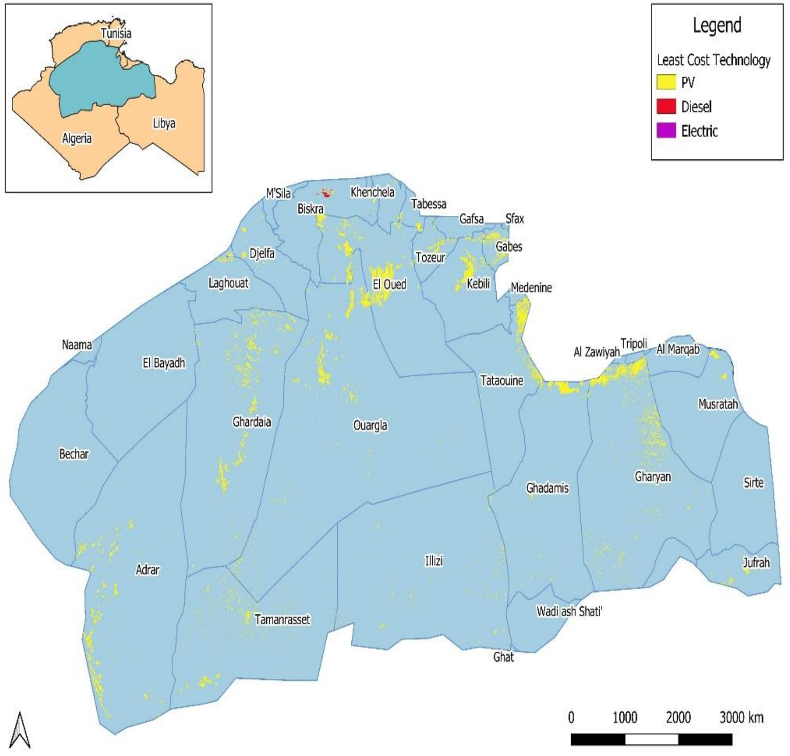
SELECTED RESULTS- THE LEAST COST ELECTRICITY SUPPLY OPTION



CAPEX level 1 (1140 USD/KW)



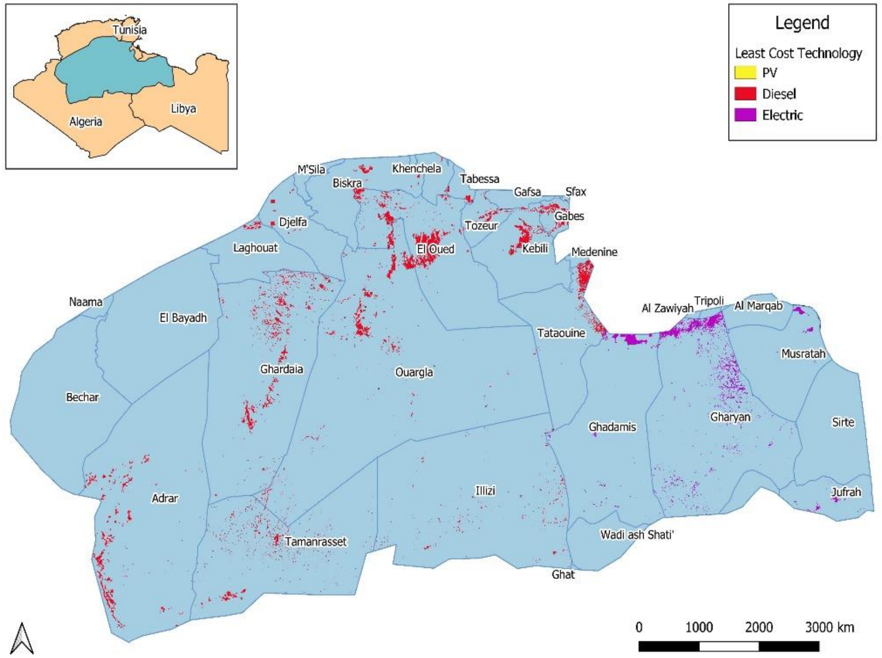
CAPEX level 2 (970 USD/KW)



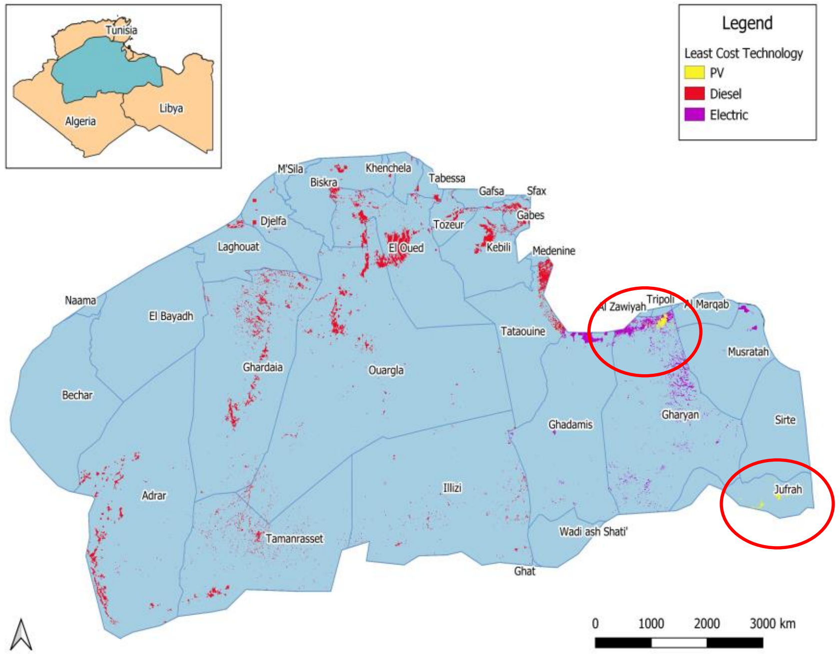
CAPEX level 3 (680 USD/KW)

Technologies	Parameter	Units	Sensitivity Levels			Source
			1	2	3	
Diesel Gen sets	Capital Cost (CAPEX)	USD/KW	938	938	938	(WB, 2016b) and (WB, 2016a)
	O & M	USD/KWh	0,1	0,1	0,1	
	Life Time	Years	10	10	10	
	Fuel Cost (Algeria)	USD/Litre	0,17	0,21	0,26	
	Fuel Cost (Tunisia)	USD/Litre	0,62	0,78	0,93	
Electric Pump	Capital Cost (CAPEX)	USD/KW	845	845	845	(WB, 2016b) and (WB, 2017)
	O & M	USD/KWh	0,1	0,1	0,1	
	Life Time	Years	10	10	10	
	Fuel Cost (Libya)	USD/Litre	0,168	0,21	0,252	
Wind	Capital Cost (CAPEX)	USD/KW	1300	1105	910	(IRENA, 2012a)
	O & M	USD/KWh	0,02	0,02	0,02	
	Life Time	Years	20	20	20	
PV	Capital Cost (CAPEX)	USD/KW	1140	970	680	(Gager and Lahham, 2019) and (IRENA, 2012b)
	O & M	USD/KWh	0,01	0,01	0,01	
	Life Time	Years	15	15	15	

CAPEX level 1
(current)
Fuel level 1
(current)

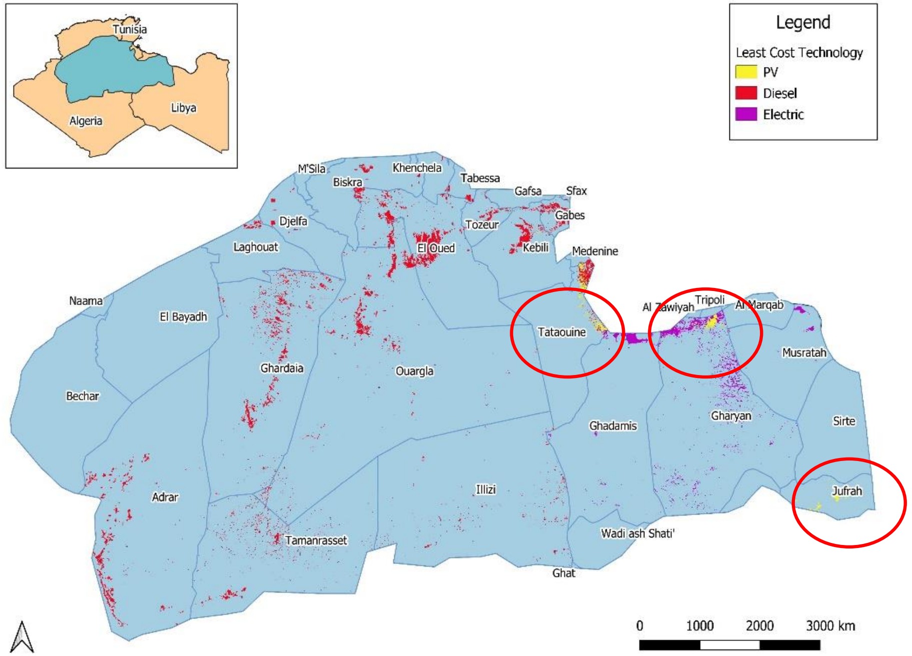


CAPEX level 1
(current)
Fuel level 3
(+50%)



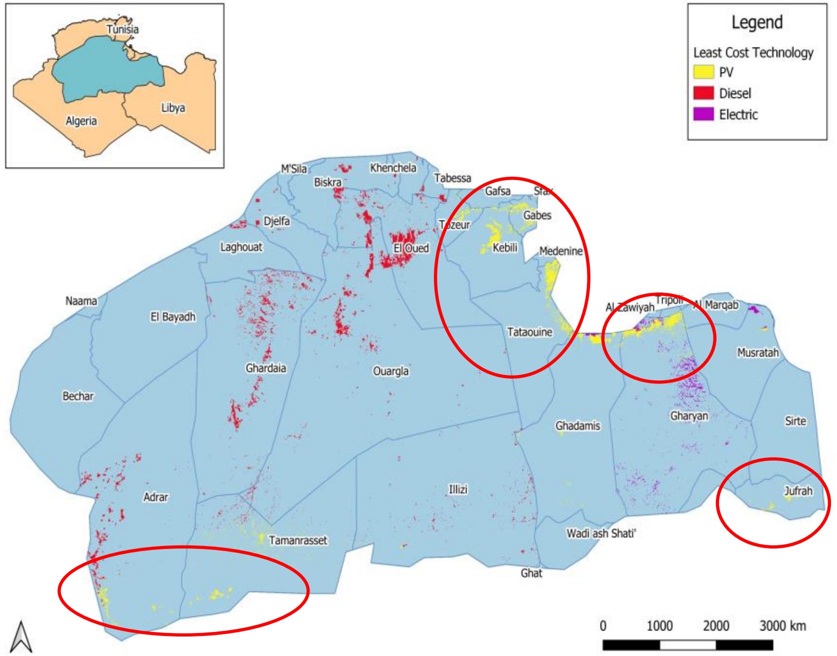
15% decrease

CAPEX level 2
(-15%)
Fuel level 1
(current)



50% increase

CAPEX level 2
(-15%)
Fuel level 3
(+50%)



KEY GENERAL MESSAGES

GIS, remotely sensed data and integrated modelling are very useful for understanding complex natural resource interactions

Tackling sustainable development challenges through **an integrated/nexus approach can maximize benefits** (and reduce cost). (e.g. investments in irrigation save water and energy). Solving many water issues requires participation of other sectors: **Inter-sectoral dialogue** can facilitate joint prioritization of issues, elaboration of solutions and synergetic actions.

Nexus assessments under the Water Convention 1) allow initiating, broadening, revisiting transboundary water/basin cooperation) and strengthening links with regional cooperation frameworks (energy, agriculture, environment) and 2) provide policy insights from modeling on key questions e.g. optimization of resource (land, water for food and energy production). An **appropriate institutional framework and engagement of key stakeholders** in the process important for policy uptake.

Data availability and accessibility is usually an issue in this type of studies which calls for another dimension of coordination in data collection, updating and sharing. **Cross-border consistency of data** requires effort and groundtruthing/validation of data necessary.

Capacity building, procedures and systems to be set in place to enable the integrated planning. Open source tools encourage transparency , reproducibility and support researchers and policy-makers to build a decision-making tool-kit.