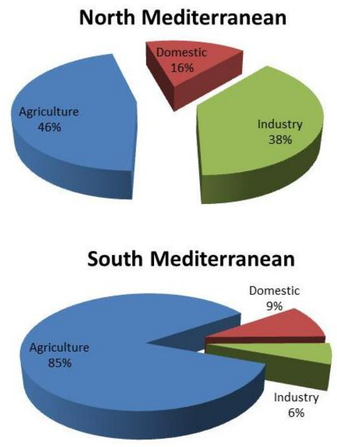
Assessing the water and energy footprint of irrigated agriculture in the Mediterranean Region

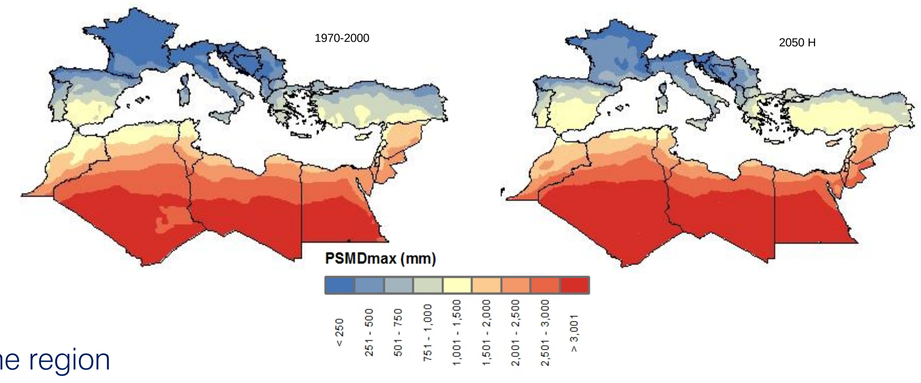
Cranfield UNIVERSITY

Water and carbon for food....

The Mediterranean is one of the water scarcest regions in the world and agriculture is the largest water consuming sector and the major source of income and employment for rural livelihoods. Dwindling water supply, increase in drought frequency and uncertainties associated with climate change have raised the alert on the food security and environmental sustainability of the region. Relying largely on ground water abstraction and on pressurized water application systems, irrigated agriculture is also an important CO_2 emissions contributor.



Agriculture is widely regarded as one of the sectors at most risk from a changing climate, due to the impact of increased temperatures, reduced rainfall and increased frequency of extreme events. It will influence the way crops develop, grow and yield. Also, the viability of rainfed production and demand for supplemental irrigation could also alter dramatically.



Long term average (1970-2001) and projected future (2050's) Potential Soil Moisture deficit ($PSMD_{max}$) (Agro-climatic indicator that is directly related to crop water needs) under high emissions scenario

Aim and objectives

- Assess the spatial water demand of major crops grown in the Mediterranean
- Estimate the GHG emissions from pumping water for irrigation
- Using current crop yield, evaluate the spatial variation in water and carbon productivity across the region
- Identify food production vulnerable zones and evaluate potential mitigation strategies to tackle water scarcity and CO_2 emissions
- Replicate the work taking into consideration the future climate, environmental and technological changes

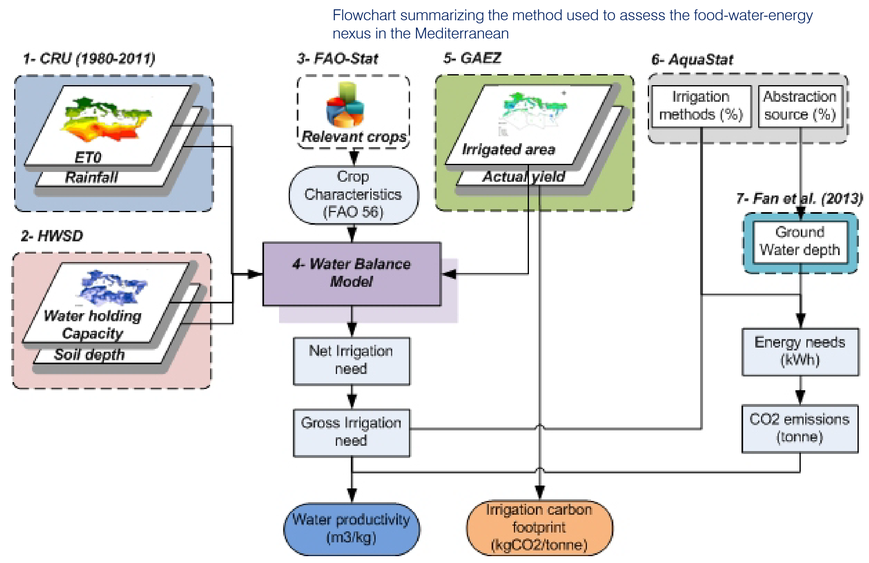
Methodology

Large geo-database of climate (Climate Research Unit 0.5), soil (Harmonized World Soil Database) and crop (Global Agro- Ecological Zones) together with national irrigation statistics (FAO-Aquastat) are used to run a spatial water balance model to estimate the crop water demand of the Mediterranean main strategic crops.

Irrigation methods and water abstraction source for each country were collected from national statistics and used together with the ground water depth map (Fan *et al.,* 2013) and the estimated water demand to calculate the energy need (kWh) for water abstraction and application on main irrigated crops. Energy was then converted into CO2e (Carbon Trust, 2011) to obtain the potential GHG emissions from irrigated the Mediterranean crops.

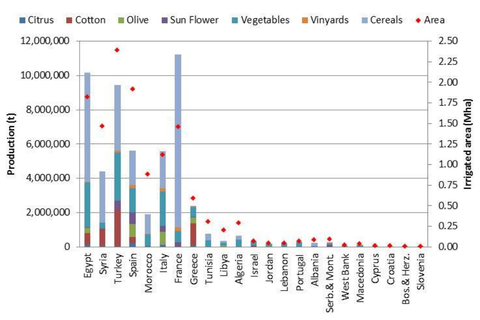
Estimated water and energy requirements to irrigate the major crop categories were related with the current yield to identify water (kg/m^3) and carbon productivity (kg CO2e/tonne).

Flowchart summarizing the method used to assess the food-water-energy nexus in the Mediterranean

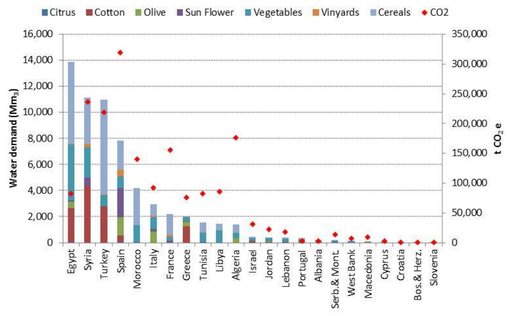


Results

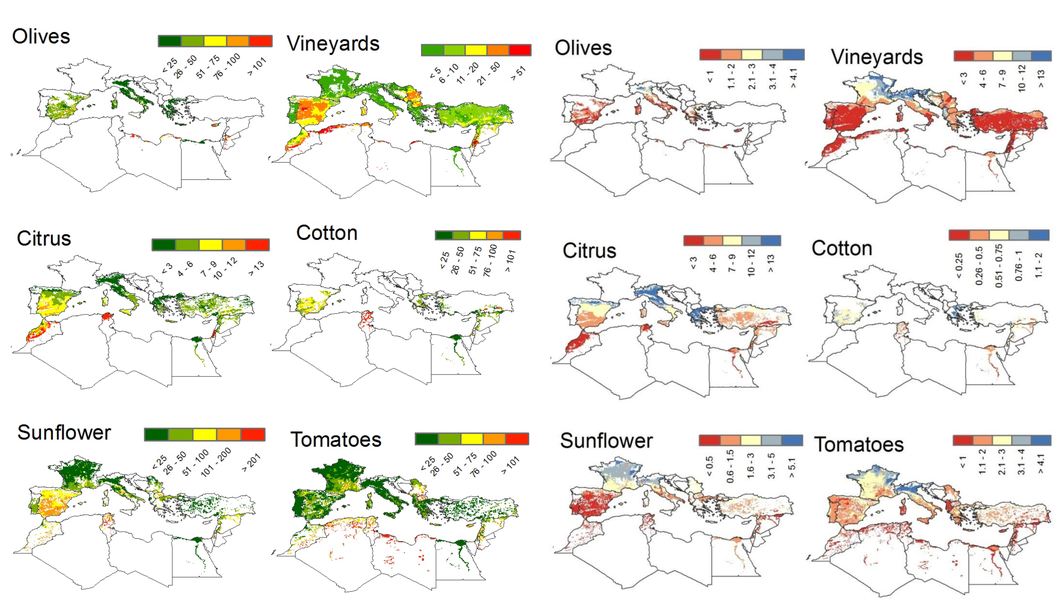
The estimated water need of the major irrigated crops in the Mediterranean in an average year was estimated to be around 61.7km^3. Egypt is the Mediterranean country with the largest water demand followed by Syria and Turkey. The estimated CO_2 emissions of Spain (236,679t CO2e) from water pumping for irrigation is almost 3 times higher than Egypt (81,988t CO2e). As a matter of fact, 21% of the abstracted water for irrigation in Spain are groundwater (less than 2% for Egypt) and less than one third of the irrigation methods are not pressurized (88% of Egypt).



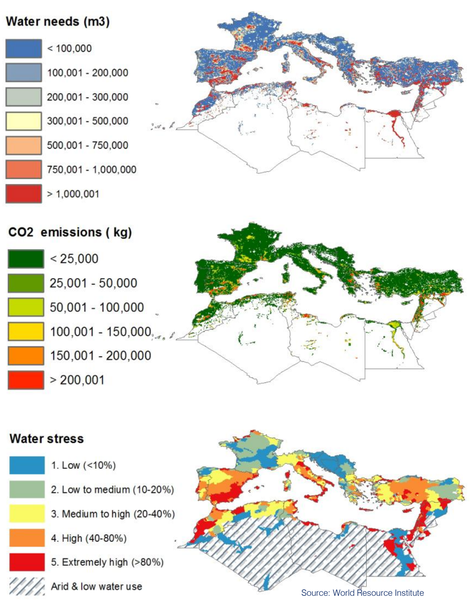
Total irrigated area and crop production tonnage obtained from irrigated agriculture



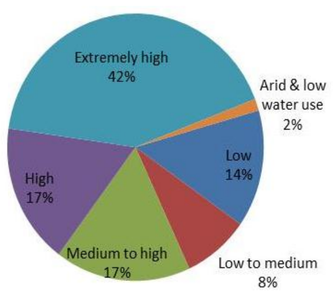
Water demand and estimated CO_2 emissions from pumping water for irrigation



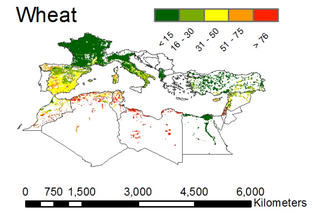
North Africa , Southern Spain and the Middle East have the lowest production per unit of water. This is largely driven by the dry climate but also in certain regions by lower crop productivity.



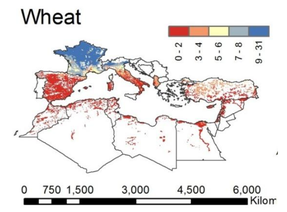
Water needs, CO_2 emissions from irrigated agriculture and water resources availability across the Mediterranean



Proportion of the total water needs of the irrigated agriculture within Mediterranean river basins classified by their water stress



Carbon emissions per crop unit (kg CO2e/tonne) of the major crops grown in the Mediterranean



Water productivity (kg/m^3) of the major crops grown in the Mediterranean

Conclusion

Currently, 59% of the irrigation demand of the Mediterranean is located in river basins with water stress risk classified as "extremely high" and "high". As the future demand driven by climate change is expected to become higher, the proportion of food/commodities produced from stressed catchments is likely to become higher unless urgent mitigation options are in place. For example shifting from surface to pressurised systems such as drip and sprinkler will reduce the water need of the current irrigated crops by more than 12% (7.8km^3) but will almost double CO_2 emissions (from 1.7Gt to 3.6Gt CO_2). This under the assumption that water table levels remain unchanged.

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