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Is irrigation with partial desalinated seawater a policy option for saving freshwater in the Kingdom of Saudi Arabia

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The agriculture sector consumes with 88 % a majority of the almost fossil water resources in the Kingdom of Saudi Arabia (KSA). Irrigation with saline water has been highlighted to be a promising technique to reduce fresh water consumption. Current desalination techniques, further developments, salt tolerant crop types and improved irrigation systems can potentially redesign future perspectives for irrigation agriculture, in particular by considering the growing desalination capacity in KSA (5 million m^3 day^{-1} in 2003). Hence, we have analyzed the potential of using desalinated and partial desalinated seawater for growing crops in KSA by considering scenarios of salinity levels and desalination costs. The desalination process has been modelled with the ROSA© software considering a reverse osmosis (RO) plant. The spatial decision support system SPARE:WATER has been applied to assess the water footprint of crops (WF_{crop}). In order to maintain high crop yields, salts need to be washed out from the rooting zone, which requires the application of additional salt-free water. Therefore, high crop yields come along with additional water requirements and increased desalination effort and increased costs for proving high quality water. As an example, growing wheat with partial desalinated seawater from the Arabian Gulf with a RO plant has been investigated. Desalination reduces the salinity level from 76 dS m^{-1} to 0.5 dS m^{-1} considering two RO cycles, with cost of desalinized water in the range of 0.5 to 1.2 \$ m^{-3}. We acknowledge that cost only refer to desalination without considering others such as transport, water pumping or crop fertilization. The study shows that Boron is the most problematic salt component, because it is difficult to remove by RO and toxic in high concentrations for crops (wheat threshold of 0.5 to 1.0 mg l^{-1}). The nationwide average WF_{crop} of wheat under surface irrigation is 2,628 m^3 t^{-1} considering high water quality of 1 dS m-1 and 3,801 m^3 t^{-1} at 12 dS m^{-1}. Using sprinkler or drip irrigation systems the WF_{crop} decreases of about 20 % and 34 %, respectively. It can be shown that a salinity level larger than 9 dS m^{-1} increases leaching water requirement of wheat over proportional and that a salinity level of 9 dS m^{-1} reduces cost for irrigation water by about 11 % in comparison to the irrigation with nearly fresh water quality of 1 dS m^{-1}. A trade-off analyses reveals that making desalinated seawater use profitable, cost need to be reduced below 0.2 \$ m^{-3} for sprinkler and drip irrigation and even below 0.1 \$ m^{-3} for widespread used surface irrigation systems.

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