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Modelling the expansion of salinity in cultivated areas of Pakistan

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An experiment was carried out at Pakka Anna, Faisalabad, Pakistan with the objective to develop suitable soil, water and crop management technologies under saline conditions for sustainable crop production. The specific objectives were:
• To manage poor quality (saline, high Residual Sodium Carbonate) groundwater for improved crop productivity in salt-affected areas;
• To investigate the impact of long-term groundwater irrigation on crop productivity, quality, and sustainability of soil/water and environment and to develop management practices for mitigating ill effects of saline groundwater irrigation on crop and soil using modelling approach.

To achieve these objectives, an irrigation study combining fresh and salt-affected water was carried out. A combination of Hydrus 1D model and AquaCrop, the FAO crop growth model was also explored to test the possibility of simulating the long-term irrigation impact. The one dimensional (1D) Hydrus is an open-source model that simulates water fluxes through soil profile as well as the fate and movements of salts. However, it requires separate evaporation (E) and transpiration (T) fluxes as input data. This limits the use of the model, since it requires field measurements that are not often available except on limited field studies. To overcome this difficulty the AquaCrop model (version 6.0) was used to simulate crop development and estimates of E and T, based on common field measurements including meteorological data, groundwater quality, soil and crop characteristics.

Salinity vertical distribution down the soil profile over time was studied at Pakka Anna, Pakistan under barley (Hordeum vulgare L.) crop for 3 consecutive seasons: 2014-2015; 2015-2016; 2016-2017. Soil evaporation (E) and crop transpiration (T) were estimated by AquaCrop using field observation of the soil, plant and the climatic data collected at the Pakka Anna weather station. Modelled E and T data was then used as an input to the Hydrus for determining the fate of the major salts (Na and Cl) in solution moving through the soil profile. Four irrigation treatments were used to investigate the impact of water management on salinization, these were: 1. optimum irrigation (100% ETc) which fully meets the crop water requirements, 2. 120% ETc treatment i.e. 20% higher than optimum irrigation of the crop. For the other two treatments (80% ETc and 60% ETc), the crop was under water stress.

The 1D-Hydrus simulation when combined with AquaCrop showed that over the study years higher irrigation application with saline water resulted in more salts accumulation in the soil profile. This is particularly true for the sodium profile. This combined method showed good agreement in results with experimental data and is currently being tested on the long-term groundwater irrigation on crop productivity, quality, and sustainability of soil/water and environment, so that management practices can be developed for mitigating the adverse effects of saline groundwater irrigation on crop and soil.