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Evaluating the impact of multi-cropping pattern and adaptive management practices on the water footprint of farmlands

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Water shortage is a major global challenge that is threatening the food security of many countries, particularly water-scarce regions. This research assesses the impact of multi-cropping and crop rotation on the Water Footprint (WF) under adaptive field and irrigation management practices. The Aquacrop-OS model and the global WF accounting standard were used to assess the total, green and blue WF of major crops in the Upper Litani Basin (ULB) in Lebanon. Unlike most water footprint/water productivity studies, this research takes into account multi-cropping, crop pattern, and crop rotation impacts on two main components of WF, actual evapotranspiration and yield in combination with the effect of different adaptive management practices. The adaptive management practices consist of mulching for all crops, drip irrigation for summer crops plus mulching for all crops, and relocation of high-value crops based on the effects of the first and second practices plus drip irrigation and mulching practices. In a combination of crop type, soil type, and climate zones, land-units were defined to represent characteristics of each land unit (e.g. harvestable crop of the season, soil, etc.). Input data were collected from our field survey in the region and the available literature from the ULB. The surveys provided geo-referenced technical information of crop, soil, water source (quantity and quality), irrigation, fertilisation, groundwater and yield; these data were partly used in the simulation process and partly in the validation process. The 5-meter spatial resolution land-use maps for three growing seasons in a year were employed as base maps to plot the spatiotemporal distribution of major crops. A crop calendar was established based on land-use maps and field surveys. Initialization, parameterisation and calibration processes took place to prepare high quality and adequate input data for the simulation model to perform well. A time series of the annual total WF of all land-units showed a significant jump in the annual WF of multi-crop land-units and land-units with summer crop cultivation. The assessment of total WF variation in different soil types and climate zones showed a minimal variation of WF in different soil types but a substantial variation over different climate zones. It confirms that the total WF was more sensitive to the climatic factors but less to the soil types. We found the annual blue WF of summer crops the highest which is at the time that water availability is the lowest in the region. The impact of adaptive management on the blue WF reduction showed a 3.6% reduction by mulching, 4.7% reduction by mulching and drip irrigation and 20.4% reduction by the relocation of high-value crops plus mulching and drip irrigation.