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Spatial groundwater resource allocation by means of extremal optimization, combined with a cellular automata component.

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The spatial allocation of groundwater resources gives rise to problems of larger scale compared to the ones originating solely from the extraction of groundwater. The spatial extension that complements extraction produces problems of greater complexity. More general spatial optimization problems, such as land use management and resource allocation have been treated by many researchers, in contrast to spatial water problems. Such problems have been presented by the first author using various meta-heuristic techniques. This paper will present the application of extremal optimization (EO) to a typical groundwater allocation problem, described briefly below:

A two-dimensional field is divided into land blocks. A number of wells are situated in the field and each land block is irrigated from one of these wells. The well assigned to each block is termed its state. The problem is to determine an optimal configuration of states over the field, with cost minimization objectives and under appropriate constraints.

EO is a stochastic method based on the function of self-organized critical systems, such as the Bak-Sneppen model. Combinatorial optimization has been the primary field of application of EO. No application of this method is noted in groundwater management.

In the present problem, EO works by identifying each block as a cell and by assigning to each cell a local value of the objective function, according to which the cells are ranked. A perturbation is then effected by exchanging the worst cell to another one at random. Improved configurations are obtained and the method is further reinforced by a local improvement rule, applied to each cell at the neighborhood level, thus introducing a cellular automaton concept into the whole method.

Special consideration is given to the compactness of the obtained configurations. The results are compared to those obtained by a spatial operational genetic algorithm, demonstrating the competitiveness of EO.