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Sustainable management of groundwater for mitigation of declining water tables in the Mid-South United States: challenges and potential solutions

Gary Feng, Yiwen Han, Ying Ouyang, and Wei Jing
USDA-ARS, Mississippi State, United States of America (gary.feng@usda.gov)

Long-term unsustainable use or overexploitation of groundwater resource have led to different degree of water table declining from arid to even humid regions across the globe. The Lower Mississippi River alluvial plain (refers to MS Delta) in subtropical humid Mississippi state, is a watershed where groundwater level has declined the most in the United States. It is even worse than any states and watersheds in the arid and semiarid regions such as Mid-West and western USA. Approximately 35 million cubic meter per day of water from the alluvial aquifer in MS Delta are withdrawn for irrigation, as a result, groundwater level has declined > 6.5 m since 1970, which threaten the sustainability of irrigated agriculture in this region. Surface water as an alternative irrigation source must be taken for sustainability of irrigated agriculture in the region. The objectives of the study were to: 1) determine the total amount of available surface water resources and its temporal and spatial variation in MS Delta; 2) simulate groundwater recharge as affected by ET based and soil moisture based full irrigation schemes using all groundwater and different percentages of surface and ground water. The coupled SWAT (Soil and Water Assessment Tool)-MODFLOW (Finite Difference groundwater model) was employed. Mean annual rainfall is 1290 mm, only 31%, 40%, and 34% of annual rainfall occurred in growing season of soybean, corn and cotton, respectively. Irrigation was required in all but 12 out of 100 years in the humid region. It was estimated that each of the three major crops required irrigation of 200 mm every year over the 100-year period. 180 billion cubic meter of ground water is required each year if all of those croplands are irrigated. The average loss of groundwater was about 5 billion cubic meter every year from 1987 to 2014 in MS Delta. There is about 0.1 million ha of surface water in the MS Delta. If only 19% of those water is used for irrigation, at least 37% of groundwater can be saved in the region. Simulation estimated that the annual available stream and pond water is 11 billion cubic meter. The amounts of weekly groundwater use for irrigation that could be replaced by surface water were 46% in May, 23% in June, 21% in July, 35% in August, and 56% in September. Results revealed that the groundwater storage was decreased by 26 cm/month due to conventional irrigation in crop season. It is promising that the groundwater storage was increased by 23 cm/month, sometimes even 60 cm/month in the crop non-growing season by recharge from rainfall. The model's simulated results suggest that using either ET or soil moisture based groundwater irrigation scheduling, along with the conjunctive use of surface water, could be a sustainable groundwater management practice in the MS Delta.