Sustainable Groundwater Management Using Water Markets

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INTRODUCTION

Increasing regulation of the world’s groundwater resources is prompting many governments to consider water markets as a water management tool. Yet despite considerable research and a dearth of new technology, few digital tools exist for creating and operating water markets. This project proposes a digital framework for a groundwater market that would allow agricultural groundwater users to exchange temporary water leasing rights over a digital exchange. The ultimate realization of this idea would take the place of a digital web application built using Python.

BACKGROUND

For decades, California’s groundwater sustainability problem has been characterized by declining water levels, increasing demand, and extreme drought. In 2014, the State passed the Sustainable Groundwater Management Act requiring 127 groundwater basins to halt overdraft and return to balanced levels of pumping. The SGMA act allows for the use of groundwater markets to manage this problem. In a groundwater market, stakeholders are given an allocation they can either use or trade to a neighboring stakeholder in the same basin.

METHODS AND MATERIALS

As part of a literature review, Raffensperger’s model was identified as the most comprehensive model for groundwater market creation. The model uses a response matrix to account for spatial variabilities in groundwater pumping. To provide a framework for a digital application, the author examined three main computational frameworks: MODFLOW, MODFLOW-GWM, and PULP, a Python library for linear programming optimization. A sample problem from MODFLOW-GWM literature was used to simulate a real world scenario in which four farmers trade for groundwater pumping rights subject to environmental constraints.

CONCLUSIONS

1. Raffensperger’s model is the most comprehensive model for groundwater market creation and represents the best chance for successfully implementing a groundwater market under SGMA.

2. The digital application that will allow water users to sell temporary groundwater leasing rights will need to be based on three computational systems: MODFLOW, MODFLOW-GMW, and the PULP Python library.

3. The creation of a groundwater market assumes proper monitoring of groundwater abstraction is possible for enforcement purposes.

REFERENCES

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Figure 1- Model grid and linear programming formulation for a MODFLOW-GWM sample problem with four candidate wells (circles) and four constraint locations (asterisks). The objective is to maximize the total water withdrawn subject to the environmental constraints.

Figure 2- Raffensperger’s evaluation of his model in a basin in Marlborough, New Zealand. User’s bids for water are entered as coefficients of the objective function in the optimization problem. The MODFLOW-GWM response matrix values are entered as coefficients in the constraint summations.

Figure 3- A Python code sample of how to utilize the PuLP library to solve an optimization problem with four wells and two constraints.