Increasing Groundwater Recharge Activity in the San Joaquin Valley of California

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Introduction

Over the past several decades, groundwater has become a primary source of water used for agriculture in California. Surface water available for agricultural use has depleted due to declining rain totals and reallocation to environmental purposes. As a result, groundwater overdraft has become a severe challenge, especially in the San Joaquin Valley of California. This excessive overdraft causes a plethora of issues, one of the most serious being land subsidence (Faunt, Sneed, Traum, & Brandt, 2016). Studies suggest some areas of the San Joaquin Valley have experienced more than a 28-foot drop in the land level since the 1970's (Alley & Alley, 2017). This is both an environmental issue and one of economics considering land subsidence is estimated to have caused in excess of $1.3 billion dollars (in terms of 2013 dollars) in damages between 1955-1972 alone (Borchers, Carpenter, Grabert, Dalgish, & Cannon, 2014). This large economic toll has grown so large that today it is difficult for economists to estimate.

To correct the detrimental course that California's water management system is on, regulations pertaining to and the monitoring of, groundwater pumping have begun to be implemented. One of these recent programs is the Sustainable Groundwater Management Act (SGMA) policy of 2014 which will affect California as a whole but, will put major focus on the San Joaquin Valley (Thomas, 2019). Though it is important to regulate groundwater pumping, more effort needs to be put into groundwater recharge, the process by which water is returned to the aquifers. As aquifers have water pumped out of them, there is limited time for the water to be recharged back in before the aquifers are compacted, and the space is lost forever (Alley & Alley, 2017).

California needs to immediately take advantage of this time and use excess surface water, especially in the cold wet months and "wet years", to recharge the aquifers. This, however, is a costly and unregulated endeavor for agriculturists. The author's research will focus on the development of recharge credit programs that have begun attracting attention in recent years. This information will be combined with testimony straight from the industry in order to develop a detailed look into the economic, environmental, and agricultural benefits of these recharge credit programs, in the hopes of increasing their use and answer the question, 'Why should I invest in recharge?'

Background

Recharging groundwater is not a new concept, it happens every day naturally and has been a longstanding practice for many agriculturists. However, due to the water conditions over the past several decades, recharge in California has tapered off, which has caused resurgence in our problems of land subsidence. With land subsidence also comes decreased aquifer holding capacity, salt-water intrusion, and degraded groundwater quality. These issues are near direct results of groundwater overdraft and are getting more serious every year. These issues have worsened conditions so much that California finally became one of the last states to formally regulate groundwater (SGMA, 2014).

To improve California's groundwater situation, legislators need to work on creating legislation and regulations that will allow for economic incentives for groundwater recharge and the establishments of water markets. In some areas of California, many water districts have already created individual programs that will reward agriculturists for recharging the groundwater. According to employees of LIDCO Inc., a Californian company that designs and installs agricultural drainage systems, some irrigation districts have adopted this practice of rewarding agriculturists with a type of credit, that can be redeemed later for reduced priced/free water from the irrigation district, when they recharge ground water. This type of economic program is extremely fruitful to both the farmer and the water district, for it promotes groundwater recharge while giving the agriculturist a useful incentive to invest in groundwater recharge infrastructure.

This, however, is not a viable solution for everyone. When the newly adopted SGMA policies begin to take effect, there are many areas in California that are not categorized within an irrigation district that will essentially be barred from groundwater pumping all together. According to Dr. Franklin Gaudi, faculty of Cal Poly, San Luis Obispo and the Irrigation Training and Research Center, these areas, known in the industry as "white areas", lie outside of existing irrigation districts primarily because they have no water infrastructure and/or a nonexistent surface water source (see Figure 1).

Hence, whereas SGMA requires documentation of an area's ability to pump groundwater sustainably, these areas will only be able to quote the rainfall they receive as a source of water. Meaning, they will only be allowed to pump as much groundwater as they receive in rainfall, which for most of these "white areas" is minimal, on average between 0-10 inches per year according to Dr. Gaudi (Gaudi 2019).

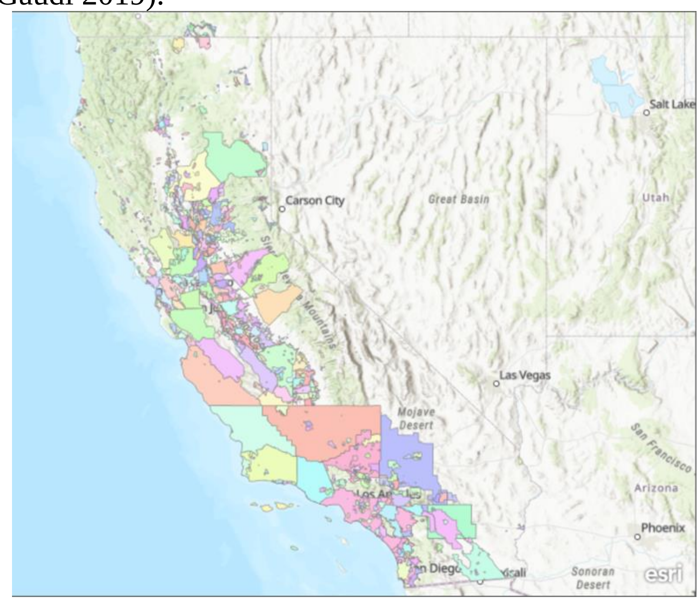

Figure 1: Map of California Water Districts, sorted by color. Areas not color coded are not incorporated in an irrigation/water district. (DWR ArcGIS, 2020)

Water markets, a long-discussed theory, are also essential to California's future. Water markets can theoretically allow individuals and water districts to buy, sell and trade water through many means. In some areas, agriculturists are already taking advantage of something similar, by purchasing land with senior water rights and using the water as the main source of income, usually with a low maintenance crop on the land as a secondary income. The creation of regulated water markets can be useful to agriculturists who struggle with low priority or restrictive water rights, such as those who would lie within the "white areas"(Jezdimirovic, Sencan, & Hanak, 2019).

Those agriculturists in areas that support water markets are also able to sell their credits. Much like stocks, the water credits could be held on to for future use or sold to another struggling operation. There are some limitations on this, however. It would be highly impractical and costly to transport water from operation to operation above ground. Due to this, most areas that support the marketing of water and water credits traditionally only do so within the shared aquifer.

Methodology

The question the author seeks to answer with this research is, how can California create policy aimed at increasing the participation in groundwater recharge projects and make recharging groundwater a more appealing investment for the average agriculturist. The methodology of this research will connect with the Cognitive Dissonance Theory, to the examination of how to get members of the early and late majority to begin participating in water recharge and water banking methods. The author will work with peer reviewed articles and sources as well as government publications and news-pieces to gather information on the subject. The author will also utilize information from professional contacts to gather the industry perspective including Dr. Franklin Gaudi from the ITRC and Cal Poly, Rocky Hampton and Glenn Drown from LIDCO Inc., and Curtis Lutje from Laurel Ag.

The product of the author's research is a cost analysis prediction model for Laurel Ag's newest project where a sub-surface recharge system has been installed by LIDCO Inc. In this section, the author will outline how each piece of the cost analysis was determined for a proper estimate. This model is a variation of one used by LIDCO Inc. for their own clients with some added features. Acreage, initial system cost, cost of water (per acre-foot, AF), pump costs (per acre-foot), and yearly maintenance costs were provided by Laurel Ag.

Value of water was determined by Laurel Ag's estimates; however, the company estimated the high value of water to be $1,000 per acre-foot. Rocky Hampton and Glenn Drown of LIDCO believed this to be too high for an accurate estimate and recommended $500. For the purposes of this estimate, the author chose the middle of both groups' estimates and used $750 per AF.

Laurel Ag estimated the company would be able to recharge approximately 820 AF of water over three years. To get to recharge per day, this was divided by three years, and then by 30 days which is the number of days any agriculturist is estimated to be able to recharge per year (Drown, 2019). This gives a theoretical recharge capacity of 9.1 AF per day based on Laurel's estimated water availability and system capacity.

The author set the high days of recharge to 60, rather than 90 like in LIDCO's analysis due to the location of Laurel Ag's operation, near Bakersfield, which experiences high heat and long dry summers. The credit rate describes the partnership between the agriculturist and the water district they belong to. In this example, the rate is 80% (provided by Laurel Ag), which means Laurel Ag will receive 80% of the water they recharge back as a credit, the other 20% is received by the water district. This credit rate varies widely district to district.

In order to account for the wide range of variability that can occur, due to weather, water shortages, etc. the author has followed the LIDCO model and created a cost analysis for four scenarios; low value of water and recharge days, low value of water and high recharge days, high value of water and low recharge days, and high value of water and recharge days. Finally in order to calculate the overall profit of the system, the author decided to use a 30-year value, which per Dr. Franklin Gaudi, is the life expectancy of any irrigation system (Gaudi, 2020).

Conclusion/Results

In the end, California's greatest hope for mediating land subsidence and subsidizing agriculturists during this water crisis is by encouraging the further development and use of groundwater recharge credit programs. The benefits of these programs are not only economically beneficial to all involved but also work to improve the environmental condition and has potential help those farmers which will struggle to stay afloat under SGMA. For in the end, the use of groundwater is an absolute necessity as it supplies globally 50% of drinking water and 40% of irrigation water (Kiparsky, Fisher, Milman, & Owen, 2017)

First, the author has showcased the economic value of groundwater recharge systems when accompanied by a water district with an established credit program. From the outcome of the cost analysis model, even in the worst-case scenario (low value of water and low recharge days) the Laurel Ag will still net $388,480 in profit, paying back the system after 11.2 years. The best-case scenario shows Laurel Ag will net $7,038,760 in profit and pay back the system in less than one complete year.

Cots Analysis of Groundwater Recharge Project	
Recharge System	Sub Surface
Water District	North Kern Water Storage District
Owner	Laurel Ag (estimations for new system)

Data for Recharge Capacity		
Acreage	100	
Initial System Cost	$ 230,000.00	
Cost of Water	$ 150.00	
Value of Water	Low	High
	$ 300.00	$ 750.00
Recharge per Day (AF)	9.1	
Recharge System Pump Cost (per AF)	$ 35.00	
Recharge System Maintenance Cost (yearly)	$ 4,500.00	
Days of Recharge	Low	High
	30	60
Credit Rate	80%	
Credits Earned Per Year	Low	High
	218.4	436.8

System Value Dependent on Variables	Gross Value (per year)	Expenses (per year)	Profit (per year)	Payback Period (years)	30 Year Profit
Low Value of Water and Low Recharge Days	$ 65,520.00	$ 44,904.00	$ 20,616.00	11.2	$ 388,480.00
Low Value of Water and High Recharge Days	$ 131,040.00	$ 85,308.00	$ 45,732.00	5.0	$ 1,141,960.00
High Value of Water and Low Recharge Days	$ 163,800.00	$ 44,904.00	$ 118,896.00	1.9	$ 3,336,880.00
High Value of Water and High Recharge Days	$ 327,600.00	$ 85,308.00	$ 242,292.00	0.9	$ 7,038,760.00

Secondly, there will be several ecological benefits to increasing recharge, especially in the San Joaquin Valley. The impacts of groundwater overdraft have devastated the San Joaquin Valley, so much so that it is often referred to as "The greatest human alteration to the Earth's surface" (Borchers, 2014). Even though most effects of land subsidence are irreversible, the best way forward is to prevent conditions from worsening and fixing the damage already done. By investing more heavily in groundwater recharge systems, we will be able to decrease further subsidence.

Another ecological benefit to recharge is the retention of groundwater basins. Basins are inherently superior for storing water as opposed to surface storage facilities. According to the 2020 CA Water Resilience Portfolio, the combined basins in California can store between 850 million to 1.3 billion acre-ft of water. This dwarfs the combined holding capacity of all of California's combined surface infrastructure only estimated to be 50 million acre-ft (California Natural Resources, California Environmental Protection, & California Department of Food and Agriculture, 2020).

By recharging more water, agriculturalists are able to sustainability access more of this stored water sustainably, and hopefully weakening our dependence on dams and reservoirs (Contor, 2009). Recharging clean water back into the ground will also help prevent saltwater intrusion (Jezdimirovic et al., 2019). This will be essential in coastal cities where saltwater intrusion is already diminishing groundwater quality.

Finally, recharging water will grant the recharger additional pumping allowance under SGMA (Jezdimirovic et al., 2019). This means a farmer who has access to a water supply in the winter can recharge that excess water and have additional pumping rights in the summer when the need is greater. Combined with an increasing network of water markets will be the only way operations that lie in White Areas will be able to get enough water to continue operating (Ghosh, Cobourn, & Elbakidze, 2014).

Overall groundwater recharge is an endeavor with many uncertainties but with many more benefits. Utilizing the economics and the environmental factors discussed in this research, the author hopes that not only will more agriculturists be convinced to invest in recharge systems, but policy makers will make programs like recharge credits more widely accessible and better funded through bonds.

References

Alley, W. M., & Alley, R. (2017). The Dangers of Land Subsidence From California's Groundwater Overdraft.

Borchers, J. W., Carpenter, M., Grabert, V. K., Dalgish, B., & Cannon, D. (2014). *Land Subsidence From Groundwater Use In California*. Retrieved from

California Natural Resources, A., California Environmental Protection, A., & California Department of Food and Agriculture. (2020). *2020 Water Resilience Portfolio*. California.

Contor, B. A. (2009). Groundwater Banking in Aquifers that Interact With Surface Water: Aquifer Response Functions and Double-Entry Accounting. *Journal of the American Water Resources Association, 45*(6), 1465-1474. doi:10.1111/j.1752-1688.2009.00378.x

Drown, G. (2019).

Faunt, C. C., Sneed, M., Traum, J., & Brandt, J. T. (2016). Water availability and land subsidence in the Central Valley, California, USA. *Hydrogeology journal, 24*(3), 675-684. doi:http://dx.doi.org/10.1007/s10040-015-1339-x

Gaudi, F. (2020).

Ghosh, S., Cobourn, K. M., & Elbakidze, L. (2014). Water banking, conjunctive administration, and drought; the interaction of water markets and prior appropriation in southeastern Idaho. *Water Resources Research, 50*(8), 6927-6949. doi:10.1002/2014WR015572

Jezdimirovic, J., Sencan, G., & Hanak, E. (2019). *Just the Facts; Groundwater Recharge*. Retrieved from

Kiparsky, M., Fisher, A. T., Milman, A., & Owen, D. (2017). The Importance of Institutional Design for Distributed Local-Level Governance of Groundwater: The Case of California's Sustainable Groundwater Management Act. *Water, 9*(10). doi:http://dx.doi.org/10.3390/w9100755

Thomas, B. F. (2019). Sustainability indices to evaluate groundwater adaptive management: a case study in California (USA) for the Sustainable Groundwater Management Act. *Hydrogeology journal, 27*(1), 239-248. doi:https://dx.doi.org/10.1007/s10040-018-1863-6