Indirect Regulation of the MRVA Aquifer: Options for the Mississippi Delta

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The Mississippi River Valley Alluvial (MRVA) aquifer supplies approximately 90% of the irrigation used in the Mississippi delta, making it an invaluable asset to agriculture and the delta's economy. Approaches to effectively manage the aquifer are being sought as per Mississippi code 51-3-1. A combination of direct and indirect regulatory approaches that take into account market forces and human nature will likely be required. This paper reviews indirect approaches to groundwater management that might help foster adoption of water-conserving irrigation practices while also aiding in the long-term management of the aquifer.

INTRODUCTION

When Pfeiffer and Lin (2010) studied the groundwater savings associated with a program that subsidized the adoption of low energy precision application (LEPA) center pivot technology in Kansas, they found that groundwater use actually increased over the 10 year study period. This occurred even though LEPA provides irrigation efficiencies as high as 95% (Howell et al., 1995) and the LEPA adoption rate among ~20,000 Kansas irrigators approached 70%. The authors determined that for every 1% increase in the percent of acres irrigated using LEPA, total water extraction increased by 1.8%, compared to what would have happened had the acres been irrigated by standard center pivot.

While this outcome is paradoxical at first inspection, it makes more sense when one considers that the LEPA-based program occurred within the context of a highly dynamic economy and environment. Such an outcome is not unique to Kansas (Ward and Pulido-Velazquez, 2008), or even groundwater (Alcott, 2005). Possible explanations for why water use in Kansas increased rather than declined as expected include (a) a worsening drought required more irrigation to grow crops, more than offsetting efficiency gains provided by the LEPA program, (2) changes in commodity prices favored production of corn over less water-demanding crops, and (3) efficiency improvements increase the total number of acres that can be reliably serviced during times of peak irrigation demand by the relatively "fixed" pumping capacities (e.g., gallons per minute per acre) of existing irrigation systems.

The key lesson from the Pfeiffer and Lin (2010) study is that irrigation efficiency improvements alone were not sufficient to cause a net reduction in groundwater use. It should be expected that in the absence of additional use restrictions or quotas, water "saved" through improvements in efficiency will be used to grow more crops as farmers universally think of 'irrigation efficiency' in terms of 'maximized economic production' rather than something that results in a net reduction in water use (Knox et al., 2011). This is not to say that improving irrigation efficiency is counter-productive per se. On the contrary, continuous improvements in irrigation efficiency will remain a necessary and critical component to water management in the 21st century. But as Pfeiffer and Lin (2010) note, "the behavioral response of groundwater users should be considered in conservation policy" but this lesson "remains unlearned, however, as many in the United States and around the world continue the subsidization of efficient irrigation technology as a method to reduce the consumptive use of water."

When human behavior is not accommodated, the expected "wet" gains of efficiency-only programs often manifest as "paper" gains as saved water is used for purposes other than preserving an aquifer (Howell, 2001).

Management approaches to address groundwater depletion can be broadly categorized as being direct or indirect (Shah, 2009; Vaux, 2011). Direct refers to managing at the level of the water user. Examples include permitting, metering, monitoring of water extraction, assessment of extraction fees, and establishing minimum well spacing requirements. Direct management works best when groundwater is being used by a relatively small number of large-volume extractors (e.g., industry; municipalities). Indirect refers to managing within the broader political, economic, and sociological segments of the water economy without directly touching the cause of groundwater depletion. Familiar examples of indirect management include education, licensing, and certification programs.

India provides an example of where indirect approaches to groundwater management are required. India has over 20 million tube wells that were installed over the past 200 years with essentially no rules or regulation, resulting in both "anarchy" and sharply declining groundwater levels (Shah, 2009). Direct regulation of groundwater withdrawals is physically and fiscally impossible owing to the high transaction costs that would be associated with metering, monitoring, and enforcement of millions of wells spread across the country. Hence, indirect methods are being sought to 'tame' rather than 'control' this anarchy (Shah, 2009).

The objective of this paper is to briefly review literature on indirect approaches to groundwater management that might be useful in (a) fostering greater adoption of improved irrigation practices in the Mississippi delta, and (b) assisting in the long-term management of the MRVA aquifer. The overall purpose is to foster dialogue and encourage outside-the-box thinking to help address the complex issue of groundwater management in the 21st century.

Lessons from Electrical Utility Behavior Programs

An area where some progress is being made in coupling advances in human behavioral science with resource conservation is the energy sector. Utilities can't mandate energy efficiency and savings at the individual user level. Thus, they are seeking indirect methods that work within the broader economic and sociological aspects of the energy economy to reduce energy demand. For example, electrical utilities have found that traditional programs that subsidize the cost of compact fluorescent light bulbs, programmable thermostats, and other energy-saving devices routinely fall short of their savings goals (Mazur-Stommen and Farley, 2013). Traditionally, these so-called "widget" programs focused on adoption of hardware and did not account for the role that human behavior and decision-making play in energy use. However, a recent study found that savings are often largest for households whose electricity use was compared directly to that of their neighbors (Mazur-Stommen and Farley, 2013; Zatlin, 2014). This phenomenon, which relates to 'social norm' aspects of human behavior where people don't like falling outside the 'norm' of their peer group, suggests that economics is not always the sole motivator of persons asked to conserve. The American Council for an Energy-Efficiency Economy (ACEEE) has grouped utility-run behavior programs into three broad categories:

Cognition programs focus on delivering information to consumers. Categories include general and targeted communication efforts, social media, classroom education, and training.

Calculus programs rely on consumers making economically rational decisions. Categories include feedback, games, incentives, home energy audits, and installation.

Social interaction programs rely on interaction among people for their effectiveness. Categories include social marketing, person-to person efforts, eco-teams, peer champions, online forums, and gifts.

In the present paper, it is postulated that it will be beneficial and even necessary to incorporate human behavioral science, similar to that being done in the energy sector, as a means to facilitate the adoption of efficient irrigation practices in the Mississippi delta and to aid in the long-term management of the MRVA aquifer. Additional selected concepts and aspects of human behavior and ways that these might be employed in the Mississippi delta to aid in the (indirect) management of the MRVA aquifer are briefly discussed below.

The Hawthorne (Study Participation) Effect

The Hawthorne effect occurs when a person's behavior is affected merely by the feeling of being observed or simply by the individual's participation in an experiment. This phenomenon has long been known as a potential source of error in human experiments (Schwartz et al., 2013). In the Schwartz et al. study, households received five postcards notifying, and then reminding, them of their participation in a study of household electricity use: The initial postcards indicated that,

> "You have been selected to be part of a one-month study of how much electricity you use in your home. This study will start on Wednesday July 20, 2011, close to the day of your meter reading this month. No action is needed on your part. We will send you a weekly reminder postcard about the study. Thank you. This study is being conducted by researchers at Carnegie Mellon University with help from your utility company."

No other information was sent except for four weekly reminders. The Control group (no postcards) and 2-yr prior usage data for each household were used for treatment and baseline energy use comparisons. The results showed that statistically-significant reductions in electricity use were measured—even though the treatment households received no additional information, instruction, or incentives to change. The effect was attributed to heightened awareness of energy consumption.

As is typical, however, electricity savings in the households vanished when the postcards stopped arriving. To extend the observed energy savings, Schwartz et al. (2013) discussed the need for a Hawthorne Strategy (Lied and Kazandjian, 1998) to 'remind people about things that matter but that can get neglected in the turmoil of everyday life.'

A Hawthorne Strategy for the Mississippi River Valley Alluvial aquifer?

In terms of the MRVA aquifer, the beneficial impacts of the Hawthorne effect on groundwater use is likely already occurring as a result of the Mississippi Department of Environmental Quality's delta metering program initiated in 2013. The very act of installing flow meters heightens awareness, reducing water use. However absent a Hawthorne strategy to 'remind producers about things that matter', such as how vital the MRVA aquifer is to the long-term economic viability of the Mississippi delta, the conservation benefits of the metering program may be relatively short-lived. Ideas for a MRVA aquifer Hawthorne Strategy to keep the conservation of the MRVA aquifer in the minds of growers include advertisements on billboards, local newspapers, radio spots, and other venues that remind growers and others how unique the MRVA aquifer is and how vital it is to the entire economy of the Mississippi delta.

Benchmarking

Another approach that could be used to sustain and perhaps even enhance the conservation benefits of the MDEQ's flow meter program is benchmarking. Benchmarking is the process of comparing one's business processes and performance metrics to industry bests or best practices from other industries (Global Benchmarking Network, 2014). An example of how benchmarking is being used by electrical utilities to

reduce energy use in homes and businesses is the myenergy program (https://www.myenergy.com/). Here, people enter in their zip code and energy use (or download it directly from their local utility) and their energy use is then compared to that of their neighbors.

A benchmarking program has been initiated for irrigators in the United Kingdom by the UK Irrigation Association (http://www.ukia.org/). This program currently focuses on potato production. Seasonal water use data is entered by the producers anonymously over the internet and water-use comparisons are made with that of their peers. The process is confidential and allows producers to see how their operations compare to a best-practice farm. The program uses a harvest index (e.g., $ per unit irrigation applied) for comparisons. If a productivity gap is identified by this process, recommended best management practices are provided.

In terms of the Mississippi Delta, benchmarking could be a natural fit for the Mississippi State University Extension's REACH program.

Real-Time Feedback

Another behavioral-science approach to conservation increasingly used by public utilities is real-time feedback. With broader adoption of 'smart' electrical meters, utilities are able to provide customers with real-time electricity usage via smartphone applications and other means. Research suggests that by providing feedback to customers on when and how much electricity they are using, consumption can be reduced by 5 to 20 percent (Vines et al., 2013). How best to use feedback as a compliment to traditional energy savings, i.e., 'widget' programs, is still being determined, but this approach fits with the business adage that 'what gets measured gets managed.'

In terms of potential application of feedback systems to help indirectly manage irrigation withdrawals from the MRVA aquifer, recent advances in telemetry and smartphone technologies could be used to create networks that provide real-time comparisons of irrigation use with a cohort of cooperating producers (Figure 1). As before, REACH farm sites would be logical test sites for this approach. A similar approach could be used to provide real-time status reports on the condition of the MRVA aquifer (Figure 2).

Aquifer "Give-Back" Program

In 2013, the Maine lobster fishery was certified as "sustainable" by the London-based Marine Stewardship Council (Trotter, 2013). The certification recognizes the decades-long effort of Maine's fishermen and fisherwomen to conserve and protect the lobster fisheries so vital to the economy and ecology of the state. Business owners that do not fish for lobsters, but whose businesses are directly tied to the success of these fisheries, have recognized that they should play a role in helping to manage Maine's lobsters too. As a result, Give-Back programs have been established whereby business voluntarily donate a small portion of their proceeds to support research and education that helps to sustain the lobsters (Lobster Institute, 2011).

The idea of 'giving back' has become part of the business philosophy of a small but growing number of business owners such as Steve Melchiskey (Jones, 2014). Melchiskey was the first to donate proceeds from his Big Claw Wine Company to the Lobster Institute, a research organization that works directly with fishermen to conserve lobsters. Mr. Melchiskey personally contacted the Institute and expressed an interest in donating. He explained his desire to donate as, "It is not okay to make money off of a resource and not give anything back." The Big Claw wine company pioneered the model that the Institute uses now for all give-back programs. They adopted his idea and have adapted it to other organizations that wish to support the institute in their research and operation costs (Jones, 2014).

In assessing the economy of the Mississippi delta, one could reasonably argue that the vast majority

of businesses in the delta owe their existence to agriculture. In turn, agriculture depends heavily on the MRVA aquifer for nearly 90% of irrigation used. As such, the decline of the aquifer is not only an issue for producers, but also all other business directly and indirectly tied to the agriculture. If an Aquifer Give-Back program were to be established in the Mississippi delta, business such as seed and chemical companies, well drilling operations, valve and irrigation supply companies, consulting firms and many others might voluntarily donate proceeds that could be used to foster education and research on the aquifer. Details as to where and how any resulting funds should be managed require additional consideration, but some of the proceeds would be used to (1) host scientists and policy experts from other regions of the U.S. and world to foster exchange of ideas and experiences on water management. Additional funds would be used to (2) provide scholarships for students training in water and irrigation science as more people will needed to successfully manage the delta's water resources in the future.

The goal of the Aquifer Give-Back program being proposed here is to broaden community awareness and appreciation of the MRVA aquifer as a world-class resource worthy of world-class stewardship. As such, it would serve as another form of indirect management of the MRVA aquifer if direct regulation is deemed infeasible. An Aquifer Give-Back program could foster a 'we are in this together' attitude that has helped the Maine lobster industry achieve prolonged stewardship of an economically and ecologically valuable resource.

Fostering a Conservation Mindset is Key

Another goal of the indirect management approaches discussed in this paper is to enhance and sustain a Conservation-Mindset present among delta producers (Figure 3). If direct regulation of the aquifer is not feasible, then alternative methods of management will be required. The alternative to direct management is indirect management. In actuality, a combination of direct and indirect approaches will be required to slow the decline of the aquifer. If the findings of Pfeiffer and Lin (2010) et al. hold relevance to the Mississippi delta, and there is no reason to believe that they do not, efficiency programs alone will not ultimately prevent further decline of the aquifer. Human nature and market forces must also be taken into consideration. In the absence of policies/programs that result in a net reduction in withdrawals from the aquifer and/or a net increase in recharge into the aquifer, the aquifer's decline will continue.

The success of the Boll Weevil Eradication program (National Cotton Council, 2014) provides historical precedence of state and local authorities working closely with producers to address a complex resource issue. There is also evidence to the contrary that serves as a cautionary tale as to what happens when laissez faire management results in vexing problems: the mismanagement of the "once-in-a-century" glyphosate herbicide (Duke and Powles, 2008) comes to mind. The complexity of resource management in the 21st century requires that we learn from past mistakes and incorporate the recent findings of human behavioral science into our management approaches (Allcott and Mullainathan, 2010). Our understanding of these issues is incomplete, as Shah (2009) notes that 'the science of how groundwater behaves is well developed compared to our understanding of how the users of groundwater behave.' However, many of the necessary policies, players, and technologies are available to address the decline in the MRVA aquifer. If properly designed and deployed, science-based methods of direct and indirect management will play key roles in protecting the MRVA aquifer, a resource of regional, national, and international significance.

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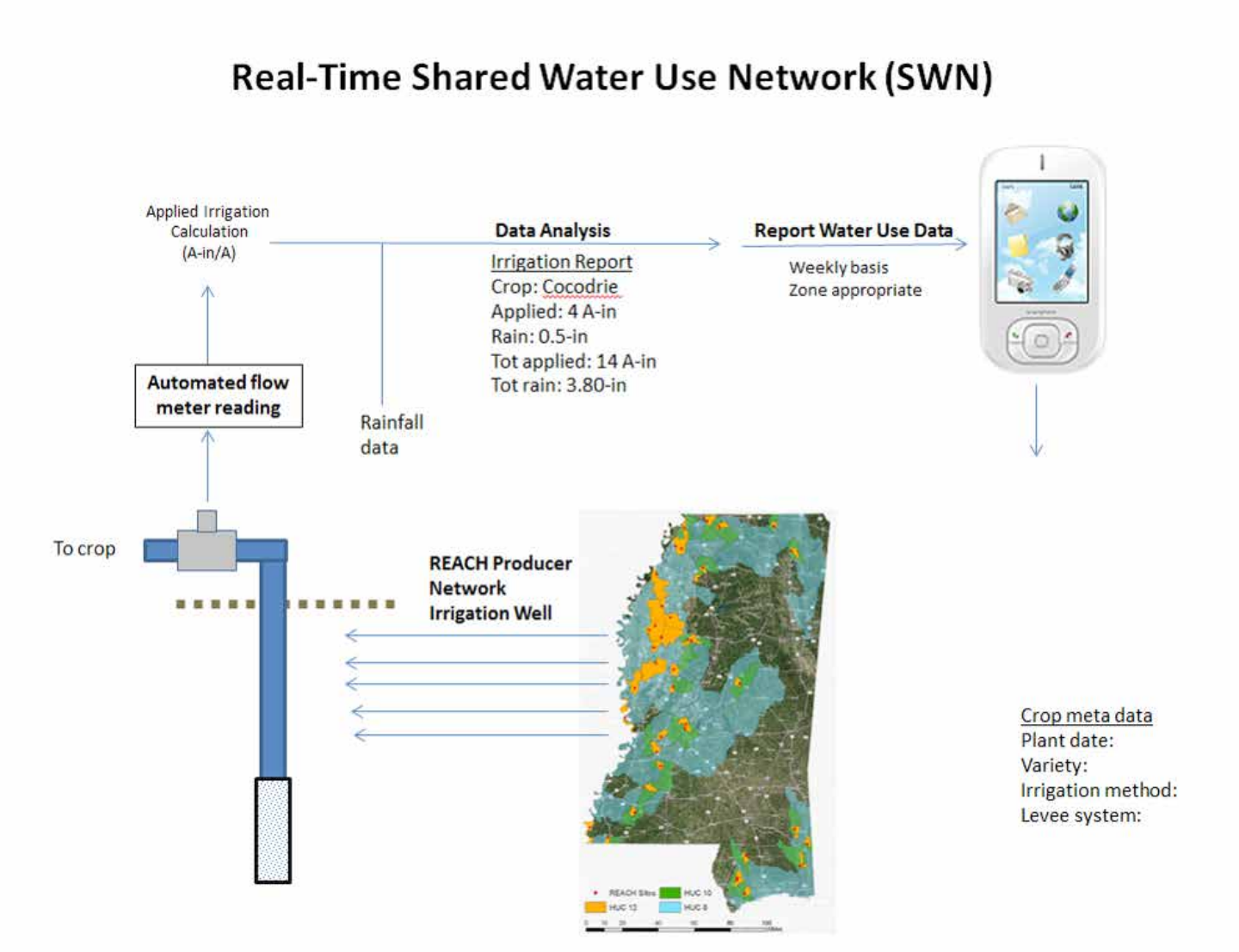
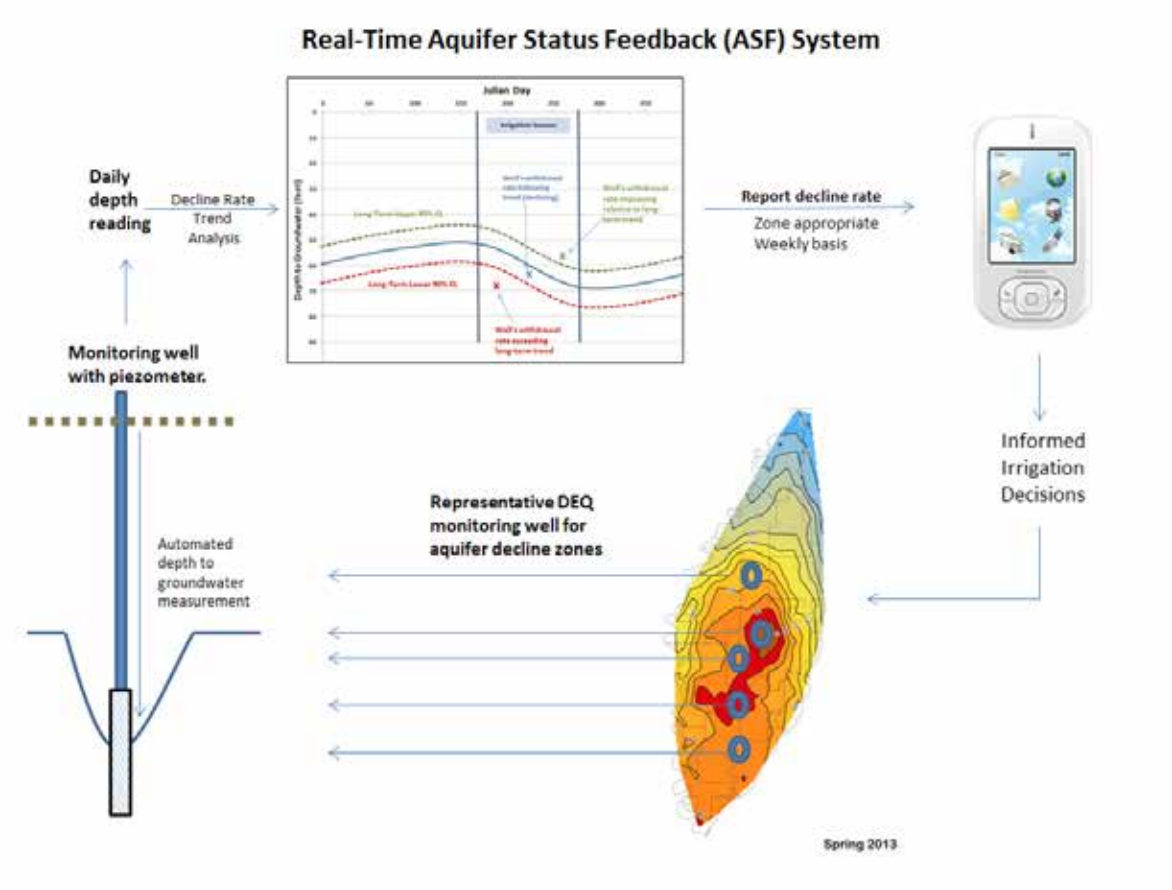


Figure 1. Conceptual design to provide real-time feedback on irrigation water use to producers in the Mississippi delta as an indirect management approach for the MRVA aquifer. (Map credit: REACH website, Mississippi State University)



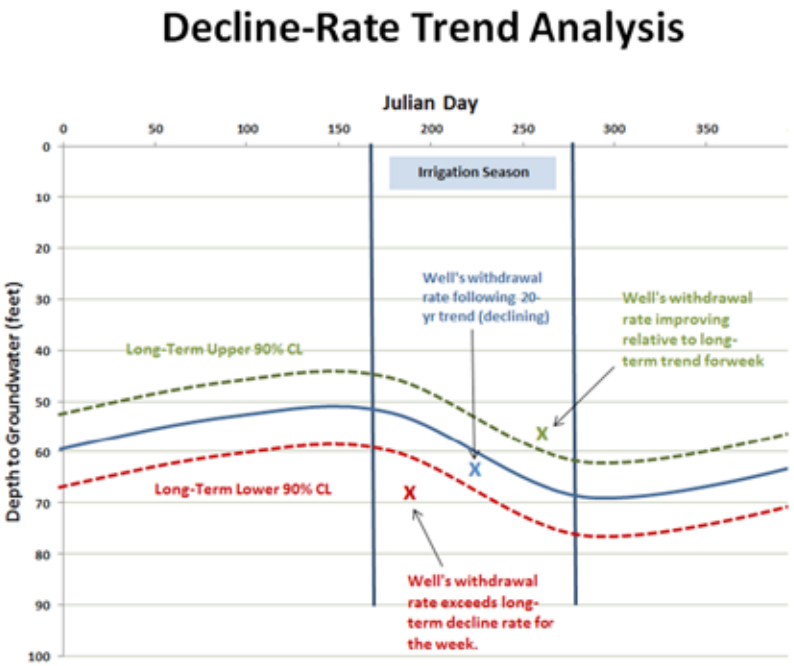


Figure 2. Conceptual design to provide real-time feedback on status of MRVA aquifer to producers in the Mississippi delta as a potential indirect management approach for the MRVA aquifer. (Map of aquifer credit: MS DEQ).

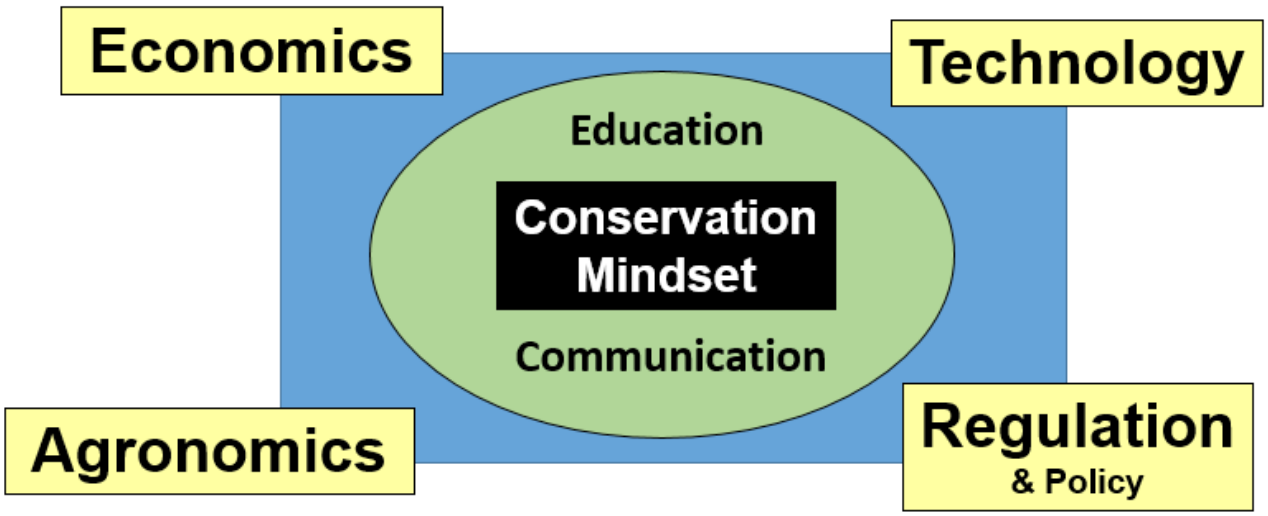


Figure 3. Components of a Comprehensive Approach to Water Management in Irrigated Row Crops.