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Cost Analysis of Converting Traditional Farms in the Wintergarden Region in Texas to Hydroponic Growing Facilities

Abstract

As Texas' population is set to double by 2050, water scarcity becomes a growing concern. Growing cities, such as the City of San Antonio, will soon compete with farmers in the Wintergarden region for groundwater. Due to the rule of capture, farmers in the Wintergarden region can legally pump as much water from the Carrizo-Wilcox aquifer as they wish. Since the City of San Antonio currently utilizes this aquifer for aquifer storage and recovery (ASR), this could be a problem in the future for the city's water supply. For this work, I investigated the possibility for the City of San Antonio to apply for a State Water Implementation Fund for Texas (SWIFT Fund) to purchase greenhouses and hydroponic growing equipment for farmers in the Wintergarden Region so farmers could continue to grow winter crops hydroponically without pumping as much from the aquifer for irrigation. This study found that purchasing the required greenhouse structure and equipment for farmers to produce 36,000 heads of lettuce per year would require approximately $68,270 per greenhouse. This analysis showed that the City of San Antonio would need to apply for a $35,000,000 low interest loan from the SWIFT Fund to create a Opt-In Program for a 500 farmers to convert their farms in the Wintergarden Region to hydroponic growing facilities.

Introduction

Water scarcity is a growing concern in the state of Texas as its population is expected to double by 2050 (Potter 2014). Growing cities like San Antonio will soon be competing with farmers and ranchers for water stored in aquifers. The city of San Antonio currently utilizes the Carrizo-Wilcox Aquifer for aquifer storage and recovery, while farmers in the Wintergarden Region 100 miles away rely on this same water source for irrigation. According to a report conducted by Texas A&M in 2012, 86% of irrigated land in Texas was irrigated using groundwater (Wagner 2012).

Due to the state's rule of capture, property owners with access to groundwater are free to draw unlimited amounts from their property (Texas A&M University), unless their property is located in a groundwater water conservation district. Many Texans rely on groundwater as their sole water source and are concerned about the future of their supply. As a result, groundwater conservation districts have been created all over Texas since the 1980's in an attempt to monitor groundwater use. Farmers have fought groundwater conservation districts on regulating their water use, claiming it to be unnecessary and violating their property rights. Farmers argue that because they depend on groundwater for their livelihood, historically they've been the first to conserve this resource, much more than nearby cities competing for the same water (Galbraith, Mar. 2012). In 2012 the Texas Supreme Court ruled that regulating groundwater withdraw was a violation of the right of property owners, on the basis of oil and gas law (Galbraith, Feb. 2012). This ruling effectively stripped groundwater conservation districts of the authority to enforce regulation on property owners, leaving farmers' and ranchers' water use to be self-managed. There is concern that as farmers continue to irrigate arid land, nearby cities who also depend on the same water source will not be able to meet their water demand in times of drought.

This report aims to investigate a potential compromise between a major city in Texas, the City of San Antonio, and the farming community in the Wintergarden Region. The compromise being that the City of San Antonio create a Opt-In Program for 500 farmers in the Wintergarden Region to convert their farms to hydroponic growing facilities while the city leases the farmers' groundwater rights beyond what is needed to run the facilities and supply water for their homes. How much would this cost? What are the benefits and disadvantages of this solution?

City of San Antonio Water Demand

As of 2018, San Antonio is the 7th most populated city in the US and the second most populated city in Texas. For the past eight years San Antonio has increased by 25,000 people per year reaching 1.5 million in 2017 (World Population Review 2018). With this rapid increase in population growth, the future of San Antonio's water supply is of utmost concern. While the city does incentivize residents to conserve water, and has diversified its water supply by utilizing desalination and reuse, San Antonio does depend on the Carrizo-Wilcox aquifer for ASR. The San Antonio Water System (SAWS) has the largest groundwater based aquifer storage and recovery in the nation, storing more than 143,000 acre feet (SAWS 2017). While the city is doing its part to reduce demand, it will likely depend on this stored water in the aquifer during times of drought. This could be an issue if the water stored in the aquifer for use during a drought is irrigated out by farmers in the Wintergarden Region.

Wintergarden Region of Texas, Irrigation Use

The Wintergarden Region is one of largest producers of winter vegetables in the country, producing high water demanding crops year round. This area typically receives around 22 inches of rain per year (US Climate data 2018) and has two rivers running through, the Nueces and the Frio rivers. However, in times of drought farmers are entirely dependent on the Carrizo-Wilcox Aquifer for their water supply. In 1995 Zavala County alone had 40,000 irrigated acres for crop production (Odintz 2010). This high amount of withdraw from the Carrizo-Wilcox could affect other users of the aquifer, such as the City of San Antonio. Studies have shown that the excess pumping from irrigation in the Wintergarden Region has resulted in significant loss of storage in the aquifer and even stream flow reversal (Huang 2012). See Figures 1 and 2 below for images of the Wintergarden Region.

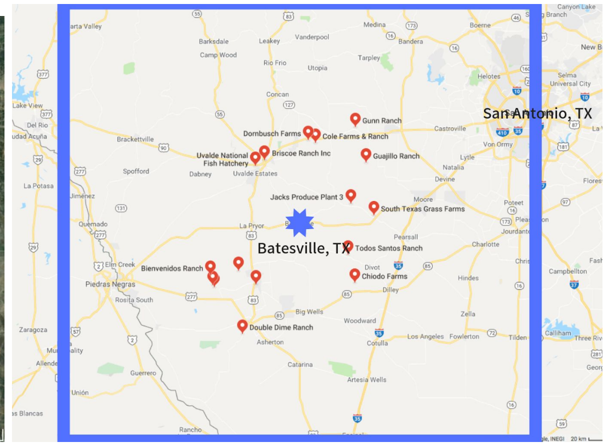

Figure 1a: Batesville, Texas, center of the Wintergarden Region. We can see from all the crop circles that this area is heavily irrigated.
Image Source: Google Earth Batesville TX

Figure 1b: Batesville, Texas is the center of the Wintergarden Region and is located approximately 100 miles southwest of San Antonio. There are several surrounding farms as this is the center of the Wintergarden Region. Image Source: Google Maps Batesville TX

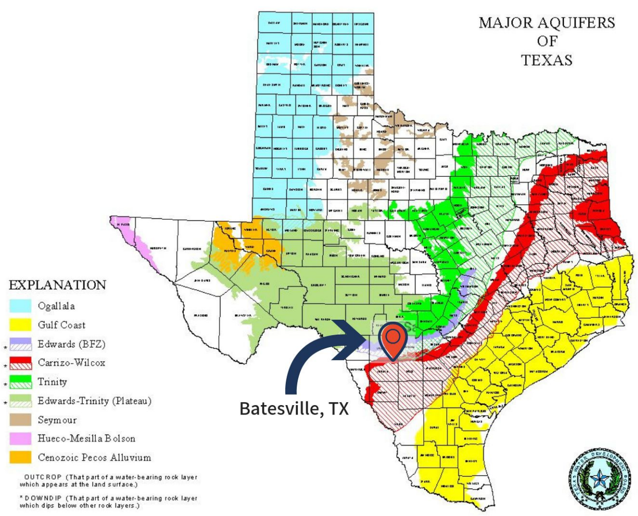

Figure 2a: Major Aquifers of Texas, with Batesville (center of the Wintergarden region) shown.
Image Source:
www.twdb.texas.gov/groundwater/aquifer/major

Figure 2b: Texas Rivers map with Wintergarden Region shown.
Image Source: geology.com/lakes-rivers-waters/texas

Hydroponic Growing Facilities

Hydroponic systems are a crop production technique where plants are grown in a soilless media and roots are submerged in a nutrient rich water. There are many different system designs; floating raft, flood and drain, nutrient film technique (NFT) and more. Each design has its own benefits and disadvantages, and different plants will grow better in different systems. Studies have shown that hydroponic growing systems overall have significantly higher yields for vegetable production than traditional farming (Agrilyst 2017). Indoor hydroponic systems also have the advantage of being able to harvest crops year round. In a hydroponic setting, lettuce planted from seed can be harvested after 35 days (Brechner and Both), as opposed to 50-100 days in a traditional outdoor farm setting (Galianto 2012). This makes for a potential of approximately 10 harvests per year in a hydroponic setting, as compared to 2 harvests per year in an outdoor farm setting. For purposes of this study, the greatest benefit to hydroponic growing systems is that they require an estimated 13x less water than traditional farming methods (Barbosa 2015). Hydroponic farms have essentially zero run off and very little water is lost to evaporation. The trade-offs to these advantages are the additional energy requirements to run pumps, cooling, ventilation and heating systems, and the upfront capital costs which can be substantial.

Estimated Costs for Construction of Hydroponic Growing Facilities

While many of the crops produced in the Wintergarden region have their own unique requirements, I chose to base cost estimates on hydroponic lettuce production, since lettuce is one of the top products in the Wintergarden Region and is known to grow very well in a hydroponic setting. To estimate the upfront costs required to build a greenhouse for a lettuce farmer in the Wintergarden Region, I used pricing information from commercial greenhouse and greenhouse equipment seller Greenhouse Megastore.com. For simplicity, I assumed farmers would require an advanced research-grade greenhouse which includes heating, cooling and ventilation systems. I also assumed lettuce farmers would be purchasing NFT systems for lettuce production. This hydroponic greenhouse setup provides a highly controlled environment for lettuce production.

It should be noted that less expensive options are available for greenhouse and hydroponic system construction. For this analysis, I calculated an upper-bound limit of upfront cost requirements to purchase the necessary equipment to build an indoor hydroponic facility for lettuce farmers. It should also be noted that this analysis does not include the additional costs for shipping equipment, installing any necessary power access, piping groundwater to the greenhouse, or the labor costs for project installation. These additional costs were excluded from this analysis since each farm will have its own unique setup and costs would vary considerably.

Research-grade greenhouse structures are available on the greenhouse manufacturer website for $45,650 each, allowing for 2,952 sq ft of grow space. This structure includes built-in heating, cooling and ventilation equipment (Greenhouse Megastore). It should be noted that the greenhouse panels are made using corrugated polycarbonate which has a lifespan of approximately 10 years, as opposed to glass panels which have a lifespan of 20+ years. This analysis does not include replacement costs of panels. NFT hydroponic growing systems are available on the greenhouse manufacturer website for $1,885 per system, occupying 144 sq ft and allowing for 300 plants per system. This system includes all necessary pumps and a reservoir tank (Greenhouse Megastore). It was estimated that 12 NFT grow systems could fit in each greenhouse, allowing for necessary aisle space for maintenance and plant care.

Summing the cost of the greenhouse structure and the 12 NFT systems, the total upfront cost for the hydroponic greenhouse and equipment would be approximately $68,270 (excluding sales tax), with a capacity of producing 36,000 heads of lettuce per year, at ten harvests per year. To provide one hydroponic greenhouse to 500 farmers in the Wintergarden Region would require approximately $34,135,000 for upfront capital costs.

Farmer Opt-In Program Benefits

The state of Texas has set aside a $2 billion State Water Implementation Fund for Texas (SWIFT) where municipalities can apply for low interest loans for longterm water saving projects. The City of San Antonio could apply for $35 million from the SWIFT fund to provide the upfront cost to Wintergarden Region farmers to convert to hydroponic farming and lease remaining groundwater rights to San Antonio Water Systems.

Creating this Farmer Opt-In Program for 500 farms in the Wintergarden Region can have many long-term benefits. It can be a compromise between growing cities who need groundwater in times of drought, and farmers who need groundwater for irrigation. Traditional irrigation methods makeup for approximately 55% of water use in the state (TWDB 2016). If farmers switched to water-efficient growing methods, they could potentially avoid future conflict with water municipalities and groundwater conservation districts.

As discussed earlier, farmers who opt-in to the program will benefit from achieving a high yield in a smaller space, and the ability to harvest year-round in a climate controlled environment. By growing winter vegetables hydroponically, they can continue their business while saving significant amounts of water. Farmers can earn extra income by leasing their groundwater rights to the City of San Antonio.

Growing crops indoors can be invaluable during extreme weather events such as drought or flood. One indoor urban farm, Acre in a Box in Houston TX, was unaffected by the effects of Hurricane Harvey in the Summer of 2017 (Martin 2017). Many other farmers weren’t so lucky, as an estimated $200 million worth of crop and livestock were lost due to the hurricane (Corey 2017). As more extreme weather events are anticipated with climate change, indoor farming is likely to be the future of agriculture.

Indoor agriculture also makes for much better working conditions for farm laborers. The ability for workers to use a restroom indoors can greatly assist with sanitation and prevent outbreaks of harmful bacteria like E. coli from contaminated crops. The ability to easily access safe drinking water and avoid excessive heat exposure during the summer months can greatly improve workers' health and productivity and prevent high turnover rates for facility owners.

Removing soil from growing facilities also allows for greater pest control. For hydroponic systems much less pesticides are required to achieve desirable yields as most pests, bacteria and fungi live in soil, not water. Because of this growing organic is much more feasible in hydroponic facilities. Farmers can earn more by selling organic produce as they can charge higher rates. Organic farming is also much better for farm workers' health and better for the environment overall.

Because water is stored in reservoirs, it possible to recycle wastewater for reuse. When reservoirs are ready to be flushed, the wastewater can be sent through filters and a reverse osmosis system for treatment and reuse. Recycling hydroponic wastewater could make growing facilities extremely resilient to drought and water shortages. This option is not feasible in traditional agriculture.

Farmer Opt-In Program Disadvantages

Despite the benefits of a hypothetical Farmer Opt-In Program, there are some disadvantages that must be addressed. The first one is the additional energy costs for running hydroponic systems. Studies have shown that hydroponic grow methods can use 82 times more energy than traditional farming methods

(Barbosa 2015). To account for this additional energy use in a sustainable way, farmers would need to obtain solar panels and battery storage, further adding to the cost. Further analysis would need to be conducted on the additional costs required to purchase or lease solar panels and battery storage for the facility.

This analysis only accounts for purchasing one greenhouse per farmer for hydroponic growing facilities. Lettuce farmers typically allot 200 acres of land for lettuce production (Smith 2009), and yield approximately 26,000 heads of lettuce per acre annually (Gallianto 2012). To convert all of the dedicated acreage to hydroponic facilities and obtain the same annual yield would require 144 greenhouses per farm. This would be beyond the financial capabilities of the Farmer Opt-In Program. As such, there would be a significant land left unused for lettuce production. To makeup this potential income, farmers could use their remaining acreage for dryland crops such as hemp, wheat, sorghum or corn.

Conclusion

Creating a Farmer Opt-In Program for farmers in the Wintergarden Region to switch to hydroponic growing methods could help secure future water in the Carrizo-Wilcox aquifer for the City of San Antonio. The city's water municipality SAWS could apply for a $35 million low interest loan from the SWIFT fund to convert 500 farms in the Wintergarden Region to hydroponic growing facilities while leasing their remaining groundwater rights to the city. Farmers could continue to run their businesses while saving water and avoiding future conflict with the municipality. Some disadvantages include lower overall yields for farmers compared to previous crop production. However extra land could be reserved for dry land farming to continue crop production without irrigation. Participating farmers would have to agree to the conservation district monitoring their well-water use, along with an annual inspection and survey of the property to ensure groundwater is being used as agreed upon. I recommend this potential

Farmer Opt-In program be further explored, for analysis on additional costs of solar power and battery storage for the greenhouse facilities, as well as the legalities of leasing groundwater from private property. If further research finds this plan will benefit both parties, it could serve as an excellent compromise to secure future groundwater for both Wintergarden Region farmers and the City of San Antonio.

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