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Precipitation Enhancement: Water Management Strategy in Texas Panhandle Region

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PRECIPITATION ENHANCEMENT: WATER MANAGEMENT STRATEGY IN TEXAS PANHANDLE REGION

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The Texas Panhandle is a semi-arid region with varied rainfall. The variation in rainfall leads to variation in the year-to-year production of agricultural products. Therefore the Texas Panhandle relies on irrigation to both increase and stabilize production. The Ogallala aquifer is the primary source of irrigation water in the region. Due to limited recharge, continued pumping from Ogallala aquifer has resulted in a declining water table. The continued requirements of agricultural, municipal, and industrial sectors emphasize the critical need for alternative water management strategies. Precipitation enhancement is one of the many water management strategies to reduce irrigation water demand.

Precipitation enhancement programs are integral parts of long-term water management and planning strategies by several regional planning groups as well as by water conservation districts and other authorities responsible for water management. This study evaluates the impact of precipitation enhancement projects on water pumped from groundwater and estimates potential water savings. The impact is measured in terms of implementation cost of the program, water savings, and cost of water savings generated.

With a conservative assumption of one-inch additional rainfall 4.11 million acre feet of water will be saved in 60 years planning period. It will be worth to mention here that the additional benefits such as livestock grazing, recreational benefits, increased water supply in reservoirs etc have not been accounted for in this analysis. This strategy is considered one of the most economical tools to assist growing populations to have enough water to meet their future needs.

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Precipitation Enhancement: Water Management Strategy in Texas Panhandle Region

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Description

The Texas Panhandle is a semi-arid region with varied rainfall. The variation in rainfall leads to variation in the year-to-year production of agricultural products under natural precipitation. Therefore the Texas Panhandle relies on irrigation to both increase and stabilize production. The Ogallala aquifer is the primary source of irrigation water in the Texas Panhandle region. Due to limited recharge, continued pumping from Ogallala aquifer has resulted in a declining water table. The continued requirements of agricultural, municipal, and industrial sectors emphasize the critical need for alternative water management strategies. Precipitation enhancement is one of the many water management strategies proposed in Senate Bill 1 to reduce irrigation water demand in Region A.

Precipitation enhancement is a process in which seeding agents, such as silver iodide, are introduced to stimulate clouds to generate more rainfall. This process is also commonly known as cloud seeding or weather modification. The cloud seeding process involves the intentional treatment of individual clouds or storm systems in order to achieve a beneficial effect without an adverse impact on human population or the environment. Dr. Vincent J. Schaefer, the father of modern weather modification, conducted the first field experiments on cloud seeding following his basic discoveries in 1946 at the General Electric Laboratory in Schenectady, New York. According to information provided by member countries to the World Meteorological Organization, cloud seeding projects are now being conducted in over 40 countries (Weather Modification Association, 1996).

The seeding agent in the process provides additional condensation nuclei for the moisture in the clouds. The process results in increased project area rainfall. The benefits that can be realized from increased rainfall from precipitation enhancement projects include increased agricultural production, economic sustainability and future growth, decreased surface and ground water consumption, increased reservoir levels, increased and higher quality forage for livestock and wildlife, and fire and hail suppression.

Documentation

In addition to oxygen, nitrogen, and trace gases, the atmosphere contains variable amounts of water vapor. The amount of water vapor that exists in a given volume of air increases as the temperature rises. Relative humidity is one measure of water vapor concentration. The atmosphere has an abundance of cloud condensation nuclei, therefore most clouds consist of small droplets of water vapor in high concentrations. Droplets in a typical cloud are so small that it takes about a million of them to make one rain drop. There are also aerosol particles in the atmosphere that cause cloud droplets to freeze or ice crystals to form directly from the water vapor. Important factors that control the initiation and amount of precipitation from a cloud are cloud size, cloud lifetime, and sizes and concentrations of the droplets and ice particles that make up the cloud. The typical large cumulus clouds have relatively few natural ice nuclei around which moisture in the air can nucleate and grow to form ice crystals or snowflakes high in the clouds, which then melt, and fall as rain. As a result, most of the cloud water vapor is never converted to raindrops.

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Introducing silver iodide provides additional ice nuclei so that more of the cloud moisture can be transformed into ice particles, which grow to precipitation size and then melt and fall as raindrops. Silver iodide is able to initiate the precipitation process earlier in a cloud, making it more efficient and producing precipitation sized particles that can survive the fall through the dry sub-cloud layer and reach the surface as measurable rainfall. Precipitation enhancement can cause thunderstorm systems to grow wider, last longer, pull in more moist air from the surface, and transform that moist air into moisture droplets. Research has shown that precipitation enhancement can cause extra cloud growth on each side of the thunderstorm. This results in a longer life for the storm system, which may cause more rain to fall over a larger area.

Research related to weather modification over the period of 50 years and cloud seeding actually being performed in more than 40 countries support the evidence that such programs operated by qualified personals are, in fact, beneficial and can increase seasonal rainfall. The policy statements on weather modification issued by both the American Meteorological Society and the World Meteorological Organization are in favor of existing technology to enhance precipitation. The scientific community (National Academy of Sciences, 1975; Sax et al., 1975; Tukey et al., 1978) has generally acknowledged the cloud seeding experiments (Grant and Mielke, 1967; Mielke et al., 1971; Chappell et al., 1971; Mielke et al., 1981) providing the strongest evidence that seeding those clouds can significantly increase precipitation. Cotton and Pielke (1995) also concluded that the evidence of significant precipitation increases by static seeding of cumulus clouds came from the Israel I and II experiments. Rosenfeld and Woodley (1989; 1993) reported encouraging results from exploratory dynamic seeding experiments over west Texas. Analyses of the seeding of 183 convective cells had indicated that seeding increased the maximum height of the clouds by 7 percent, the area of the cells by 43 percent, the durations by 36 percent, and rain volumes of the cells by 130 percent.

Researchers from the Texas Natural Resources Conservation Commission (TNRCC) have assessed the rain enhancement of the Colorado River Municipal Water District (CRMWD) from 1987 to 1990 and concluded that timely seeding with silver iodide prolongs the life of convective clouds, processes more moisture and produces significantly more rainfall. A statistical evaluation of the CRMWD's 25 years program has revealed that rainfall had been increased by 20 to 30 percent during the years of seeding. It has been found that rainfall totals to be 2.5 to 4 inches above normal during seeded years. In another study, rainfall data from a 5-year cloud seeding program conducted for the City of San Angelo also supported the evidence that rainfall during the months of seeding had been increased 25 to 42 percent in the area where the seeding was concentrated.

The Texas Department of Agriculture had been conducting evaluations of ongoing seeding activities in Texas. Results of these evaluations for 2002 indicate that all seeded thunderstorms in Texas (n = 897) have generated an additional 481,252 acre-feet of water with an approximate total cost of $4.8 million. This translates into one acre-foot of water at the expense of $10 through cloud seeding activities. It can be considered the most economical way of increasing water supply after natural precipitation that is totally free of charge (TDLR, 2004).

Research Objectives

The specific objectives of this study are to evaluate the impact of precipitation enhancement projects on water pumped from groundwater irrigation sources for Region A and to estimate potential water savings that will be generated by the two programs operating in the area.

The cost of water savings is calculated using the annual cost estimates of North Plains Groundwater Conservation District and Panhandle Groundwater Conservation District.

Methodology

Precipitation enhancement programs are integral parts of long-term water management and planning strategies by several regional planning groups as well as by water conservation districts and other related authorities responsible for water management. There are two projects in the Texas Panhandle Water Planning Area (Region A), which were established in the spring of 2000. Both programs cover approximately 8.2 million acres as their target area. The North Plains Groundwater Conservation District (NPGCD, 2004) and the Panhandle Groundwater Conservation District (PGCD, 2004), administer these two programs in Region A. For these two programs, seeding aircrafts are launched from airports in Dumas and Pampa, respectively. NPGCD now owns the plane, building and other equipment to continue the program. Annual operating expenses have estimated as $200,000 (Bowers, 2004). PGCD has spent about $176,456 during 2003 as total cost of the program, out of which up to $88,228 was funded by the state. The district owns all the equipment, including planes that have been fully paid and estimates to incur about $200,000 annually as operating expenses to run the weather modification program. Both the districts anticipate no funding from state for year 2004 and in future.

This strategy determines the impact of precipitation enhancement activities in Region A. The impact is measured in terms of implementation cost of the program, water savings, and cost of water savings generated. The data source for the analyses is the Region A Water Demand Model that had been developed in Senate Bill 2-Task 2 Report (Marek et al., 2003). The effective rainfall available to crops was recalculated after considering the additional rainfall available due to precipitation programs and the revised water demand based on the crop acres in each county in Region A was estimated for the planning period 2001-2060. The difference between the water demand with implementation of the strategy and without the strategy is the amount of water that will be pumped less from the groundwater resources. Thus the difference in water demand is considered the potential water saving due to implementing the precipitation enhancement program in Region A.

Economic Analysis of Precipitation Enhancement Programs

Since 1997 the Texas Legislature has assigned different state agencies to dispense funds for weather modification programs in Texas. Initially, the Texas Natural Resource Conservation Commission was given this task, then in 2001 the Texas Department of Agriculture, and in 2003 the Texas Department of Licensing and Regulation was responsible for the task. All of the ongoing cloud seeding programs in Texas receive state funding appropriated by the 77th Texas Legislature. In fiscal year 2002 about $2.4 million in state funds were provided to supplement rain enhancement programs currently in operation in Texas. In 2003 fiscal year about $1.9 million were granted to cloud seeding operations for rain enhancement/weather modification. State funds are allocated to these projects according to permitted target area of each project up to 50 percent of the costs to conduct them. The total cost of cloud seeding in Texas is estimated at about 7 to 9 cents an acre. State funds appropriated for 2002-03 have been exhausted and no new funds are currently available beginning fiscal year 2004.

The PGWC District conducted its precipitation program in 2003. The average project cost has been less than 4 cents per acre because the district owns the equipment. The district

presently plans to continue this program indefinitely despite a non-availability of funds from the state at present (PGWCD, 2004). The North Plains Groundwater Conservation District also plans to continue its weather modification program even without any future support from the state.

Baseline Analysis

Precipitation enhancement was considered one of the management strategies by many water-planning regions during the first regional planning cycle. It was assumed that there were no acres utilizing benefits of precipitation enhancement in the baseline year of 2000. Therefore projected water saving due to use of precipitation enhancement as a strategy was estimated as zero acre-feet (Almas et al., 2000). From the year 2001 to 2060, it has been assumed that all irrigated acres will be receiving the benefits of the precipitation enhancement programs being conducted by the two water conservation districts in Region A.

Results

It is assumed that any additional rainfall in the area will reduce pressure on pumping water from groundwater resources especially for irrigation purposes. The assumed additional rainfall due to cloud seeding and weather modification programs in the area ranges from one inch to two inches during the cropping season of six months (April to September). The distribution of that additional rainfall has also been taken into account for calculating the water requirement for each crop in each county and then the revised water demand is calculated using the methodology used in Task 2 of the Senate Bill 2 water planning project for Region A. The estimated water savings are then calculated as the difference in water demand with and without the implementation of the precipitation enhancement strategy. The rainfall distribution assumptions have been based on the historical trend of rainfall during six months of cloud seeding operations. Analyses of historical rain data from 1940 to 1997 for the 21 county area in Region A indicates that 73 percent of annual rain falls during April to September and the distribution of rainfall in these six months is 11 percent, 20 percent, 20 percent, 18 percent, 17 percent, and 14 percent, respectively. The historical distribution has been used to calculate the effective rainfall.

The projected water savings of one inch per acre assuming a historical distribution have been compiled and presented in Table 1. The implementation costs of the strategy including yearly operating cost, airplane replacement cost every 20 years and the cost of water saved on per acre-foot basis are also given in Table 1. It is estimated that 4,105,680 acre-feet of water is saved from 2001 to 2060 by continuing precipitation enhancement programs in Region A with the assumption that one inch of additional rainfall is generated during each year. This equates to a 3.89 percent reduction in the total projected irrigation water use. The total cost of generating the water saving is estimated to be $25.80 million over the 60-year planning period. Thus, the cost of water saved comes to $6.28 per acre-foot.

Table 1. Estimated Affected Acreage, Cost of Implementation, Regional Impact, Water Savings, and Cost of Water Savings							
	2010	2020	2030	2040	2050	2060	**Total**
Affected Acreage	1,502,159	1,502,159	1,502,159	1,502,159	1,502,159	1,502,159	
Implementation Cost (Millions)							
Operating Expense	$4.00	$4.00	$4.00	$4.00	$4.00	$4.00	**$24.00**
Aircraft Replacement		$0.60		$0.60		$0.60	**$1.80**
Regional Impact (Millions)							**$0**
Water Savings (Acre-Feet)	684,280	684,280	684,280	684,280	684,280	684,280	**4,105,680**
Cost of Water Savings Generated ($ per Acre-Foot)							
Implementation Cost / Water Savings							$6.28
Regional Impact / Water Savings							$0.00

Summary and Conclusions:

The precipitation enhancement programs in Texas and other parts of the country are being operated to reduce groundwater pumpage. The cloud seeding projects use the latest technological developments in science to chemically squeeze more rain out of clouds. Water conservation districts and county commissions have generally accepted the technology of precipitation enhancement as one element of a long-term, water management strategy. Assuming one-inch of additional rainfall is generated under this strategy, 4,105,680 acre-feet of water will be saved, or 3.89 percent of the total projected irrigation water use. The cost of generating these water savings is $25.8 million or $6.28 per acre-foot. It should be noted that additional benefits such as livestock grazing, recreational benefits, increased water supply in reservoirs, etc. have not been accounted for in this analysis. This strategy is an economical tool to ensure that growing populations have enough water to meet their future needs. To date, however, there is no statistical proof that the concept produces more water.

A detailed economic analysis is also needed to find out the worth of an acre-inch of water from additional rain due to precipitation enhancement activities and its impact on crop production in 21 county area of the Northern High Plains of Texas (Region A). Major crops grown within Region A include corn, cotton, sorghum, soybeans, and wheat. The estimated increase in agricultural production, based on the data available through the Texas Cooperative Extension (TCE) AgriPartner Demonstration program, has an estimated market value of $20.0 million with an impact on regional economy to the extent of approximately $70.2 million.

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