'AN INTEGRATED APPROACH TO WATER CONSERVATION FOR AGRICULTURE IN THE TEXAS SOUTHERN HIGH PLAINS'

Final Report
to the
Texas Water Development Board
TWDB Contract No. 1413581688

TAWC
TEXAS ALLIANCE FOR WATER CONSERVATION

AUGUST 10, 2022

An Integrated Approach to Water Conservation for Agriculture in the Texas Southern High Plains

Executive Summary

This summary report encompasses the full effort of TAWC from its creation in 2004 through 2020 even though the period for TWDB Contract No. 1413581688 spans 2014-2020. Funding through the Texas Water Development Board (TWDB) has been the primary support for this project from its inception. These funds have seamlessly supported a successful and unique alliance of universities, government agencies, commodity groups, communities, and producers that promote water conservation through innovation, technology and education. We do not feel it is appropriate to compartmentalize the efforts of TAWC and the impact and value returned through our TWDB funding across the life of this project.

Mission:

To conserve water for future generations by collaborating to identify and transfer agricultural production practices and technologies which, when integrated across farms and landscapes, will reduce the depletion of ground water while maintaining or improving soil health, agricultural production and provide enhanced economic opportunities.

Approach:

Conduct engagement/outreach activities to provide information to producers, industry, government and other stakeholders to accomplish water savings and soil health through demonstration and education.

- Engage in partnerships with public, private, and government entities dedicated to sustaining economic viability of Texas agriculture for all agricultural commodity groups and organizations.
- Explore conservation and sustainability from both a field level as well as systems level approach.
- Generate inter-disciplinary collaborations and provide education and outreach to assist producers in irrigation management, water conservation, and improved soil health.

TAWC Focus:

Our future focus addresses improving irrigation efficiency, crop resilience to weather extremes, and the enhancement of soil health that include:

- Demonstrate methods of minimizing soil disturbance and managing multi-species cover crops to capture and store more moisture, thereby reducing irrigation needs and conferring plant-cover resilience.

- Quantify the role of partial-field fallow and rotation of cover crop and commodity crop in conserving soil water and reducing irrigation needs.

Water conservation and soil health are intertwined in complex soil-water relationships that are complementary and vital to sustainable production agriculture. Improving aspects of soil health related to organic matter and aggregate structure can result in water savings through better soil water-holding capacity, increased water infiltration, and improved soil nutrient levels resulting in increased crop yields and economic sustainability.

TAWC Objectives:

- Monitor soil water balance and vegetative cover with crop residues and cover crops on selected producers' fields where minimum tillage, crop rotation, and multi-species cover crops are compared with conventional tillage and no cover crops.
- Analyze economic profitability of the innovative management practices at the demonstration sites by working with participating producers in collecting data on all crop inputs including irrigation and cover-crop costs and amount and value of crop yield.
- Demonstrate and disseminate results to area crop producers through on-farm demonstrations, field days, presentations, and on-line information guides, and instructional videos.

What More Can Be Achieved:

- Expand the number of producer demonstration sites to an even broader area, involving diverse soil types and water availability so that producer-collaborators can have a direct influence over a wider region.
- Incorporate further, the use of the Fieldprint Calculator from the Keystone Alliance for Sustainable Agriculture to measure energy and carbon footprints and add metrics for a water footprint feature. Documentation of water-saving practices could increase product marketability through consumer perceptions and proven sustainability.
- Measure the potential economic benefits of sustaining long term water use from the aquifer beyond the farm gate and on to the municipalities and industries. Demonstration of economic impacts illustrates TAWC as a model for use across Texas and other semi-arid regions.
- Enhance the web-based tools, *Resource Allocation Analyzer* and *Irrigation Scheduling Tool*, to achieve higher precision for specific fields and add crop species and dryland options to gain wider applicability and use outside the High Plains region.

Producer Responses and Barriers to Overcome for Wide-Scale Adoption:

- This project has increased farmer understanding of water availability and improved irrigation management practices by their own monitoring of the soil and water meters, moisture probes, and crop yield.
- Farmers can be segmented by their different approaches to using TAWC data. Adopting water-conservation practices necessitates multiple strategies for encouraging change.
- Understanding personal networks among the farmers and their willingness to adapt is crucial to increasing adoption of water conservation strategies and technologies.

- High cost of installing new technology and equipment, competing technology from different companies, and limited time to learn their operations are major barriers to adopting new, water-conserving technologies.
- Incomplete knowledge by crop consultants of new irrigation technologies slows adoption.

Through the efforts of TAWC, we feel we have accomplished more with less and overcome many barriers to wide-scale adoption. This has taken many years of building trust and recognition through partnerships with industry, government agencies, universities, communities, and producers.

Scope of Work:

Task 1 Location of Demonstration Sites and Development of Producer Board

Demonstration Sites: In consultation with the Producer Advisory Board, the location of demonstration sites were altered to reflect resignation of some Phase 1 cooperators and inclusion of new cooperators. The latter included some cooperators who were part of the USDA-Natural Resources Conservation Service funded Conservation Innovation Grant (CIG) project. These sites extended the Texas Alliance for Water Conservation focus area into 7 additional counties. Monitoring equipment was moved from old to new sites and purchase of new equipment was made as needed. A similar array of the Phase 1 crop species, cropping systems, livestock systems, and types of tillage and irrigation were included to maintain consistency with Phase 1 of this project.

Producer Advisory Board: The Producer Advisory Board in Phase 2 was maintained with the same structure (cooperator/producers only with one chair, vice-chair and secretary), and duties as in Phase 1. In 2014, one new cooperator/producer replaced one retiring member on the Board of nine members. The Board decided on which producers joined the Board and which new sites were to be included.

Task 2 Project Administration and Support

Administration structure followed Phase 1, with several personnel assigned to this task. The overall Principal Investigator and Project Administrator was Dr. Chuck West who supervised overall project management, budgeting, report submissions, and planning until his retirement in December of 2020.

As Project Director, Rick Kellison worked closely with the Project Administrator and was charged with day-to-day management, coordination of the task leaders' duties, and chairing the monthly management team meetings. Responsibilities included ensuring that data was obtained in a timely fashion and provided data collection points for analysis and summary, ensured that all reports were prepared to meet deadlines, coordinated outreach activities, provided technical advice as needed to all personnel and producer/cooperators, and pursued additional funding opportunities. The Project Director worked directly with the producer/cooperators, the scientist cooperators, the Texas Water Development Board, and the public to facilitate communication and insure appropriate flow of information.

A secretary/bookkeeper (50%-time position) supported the project until January 2016 but left due to health issues. Responsibilities included preparation of reports from information provided

by the team members and keeping of records of all expenses incurred by this project. Quarterly status reports and expense vouchers and annual reports were provided to the Texas Water Development Board.

A research associate (20%-50% time position) assumed duties of the secretary/bookkeeper, as well as continued quality control of data, submission of quarterly and annual reports, generation of graphic materials for presentations, and providing technical support for all meetings. A database containing data obtained from each site via telemetry or physical site inspection has also been created and maintained. Total crop water use of each monitored site was calculated annually using the beginning and ending soil moisture content (as available), irrigation inputs and effective rainfall received according to TWDB specified calculations. The crop yield was obtained from producer records in order to calculate the water use efficiency (WUE) of each demonstration site. Water conservation savings were calculated for each type of crop and irrigation method. The general approach used to estimate water savings within the project measured the level of crop ET provided by irrigation relative to total crop water demand (100% of ET). If irrigation was less than 100% of ET, then the difference was considered a potential savings in irrigation based on the assumption that irrigation in excess of 100% ET would not enhance yield. However, that method has limitations because the actual amounts of irrigation applied and depended on many other factors.

A technical consultant was subcontracted as a programmer for web tools and for major upgrades of the TAWCsolutions.org web site, which contains tools for producers and other stakeholders to calculate farm-scale resource allocation, field-scale irrigation scheduling, and other functions.

Two crop consultants, Dan Krieg and Bob Glodt were contracted for partial years to provide technical information on crop development and crop and water management to the Project Director for educational and outreach uses and called on to present talks and demonstrations at field days/field walks to growers, commercial representatives, private consultants, and public sector advisors and technicians.

Task 3 Extension Program (Subcontract to Texas A&M AgriLife Extension)

Extension program specialists provided support to cooperator/producers who elected to take part in the FARM Assistance program to collect descriptive crop and livestock production data and financial data that encompass the producers' whole farm/ranch operations. The FARM Assistance program provided individual analyses, financial projections, and management recommendations to those producer/cooperators on a request basis. These data were available anonymously to the economics group (Task 4) for regional economic modeling. The program specialist assisted with compiling aggregate data and reports for communication and collaboration throughout the entire project. The specialist assisted in presenting workshops for crop consultants, AgriLife-Extension agents, and cooperator/producers on the use of tools contained within the TAWCSolutions.org website.

The specialist also presented talks at field days, conferences and field walks, plus contributed generalized production information to the communications group (Task 6) for education and information programs. The task leader and specialist served as a communications bridge with AgriLife-Extension agents to arrange for their participation in field walks, field days, technical

workshops, and information dissemination.

Task 4 Economic Analyses

The economic assessment of the demonstration project expanded the economic and agronomic data sets complied from Phase 1. The joint effort between Texas A&M AgriLife Extension, Texas A&M University and the Department of Agricultural and Applied Economics (AAEC) at Texas Tech University developed and maintained detailed records of inputs and production inputs to develop annual costs and return budgets for each farm production scenario. These records and budgets provided the base data for economic studies to determine the economic impact of observed technologies for producers.

The economic data and analysis facilitated the enhancement of the TAWC Solutions tools and the development of additional tools to assist producers in decisions regarding irrigation water allocation among alternative enterprises, and adoption of water conservation strategies and technologies. Metrics regarding water conservation in agricultural production systems were addressed to better define measurement of water conserved through conservation practices and technologies. This effort was in conjunction with Task 5 and 7 to identify the factors driving water conservation in row-crop and forage-livestock systems, respectively. The purpose was to develop a regional definition of sustainability that incorporates water conservation into the broader measure of soils, carbon and energy.

Analyses was conducted to model the effects of aquifer depletion and crop choice on farm level and regional economics, and crop and livestock productivity. This consisted of integrating efforts from Tasks 4, 5, and 9. Task 4 consisted of the economic analyses as described above. Task 5 contributed data on crop water demand and evapotranspiration in relation to irrigation supply, weather, soil, and other crop factors. Task 9 contributed data and relationships on pumpage and water applied, season-long water balance, depth to water, and saturated thickness on producer sites and across counties comprising the High Plains Underground Water Conservation District.

Task 5 Water Use, Irrigation Scheduling, and Climatic Effects

With the successful launch of Landsat-8, medium-resolution multispectral satellite imagery of the project and surrounding region data was readily available free of charge for use in aspects of the project related to crop growth and water use. The availability of these imagery and quantitative data in addition to weather observations from the West Texas Mesonet (network of weather stations with daily weather data at www.mesonet.ttu.edu) allowed the operational implementation of the Advanced Irrigation Scheduling Tool, which enhanced capabilities over the current tool and made irrigation recommendations specific to individual fields. Information related to water use and evapotranspiration was to be developed for additional row crops, and annual and perennial improved forages for grazing, hay and silage. These studies were supplemented by the acquisition of two additional eddy covariance systems to increase the amount of evapotranspiration data that could be collected from field sites in the project. Evapotranspiration, crop water use, irrigation, precipitation, and soil water data were used to objectively determine irrigation efficiency and water savings. The satellite-based technology previously developed in the project, coupled with historic well measurements available from the High Plains Underground Water Conservation District, were used to determining the relationship between crop production and aquifer depletion for the area of the Project and surrounding region.

Task 6 Communications and Outreach

Phase 2 developed an enhanced level of outreach featuring a series of field walks to cooperator farms for hands-on observations and analysis of water management as the crops developed over the cropping season. Publicity of the field walks were facilitated with frequent broadcasting of events and crop and water management tips during the main growing seasons. There was also closer communication with crop consultants about new technologies for improving water conservation. Methods were developed to track effectiveness of information transfer, and to identify opinion leaders among producers, so that technology and information transfer would more effectively trigger water management improvements.

Previous project efforts illustrated that West Texas farmers and ranchers are multi-channel information consumers. Consequently, project information dissemination (including research results) has been conducted through a variety of channels that has included face-to-face, print, broadcast (radio & TV) and electronic (web, Facebook, Twitter, YouTube) formats (e.g. presentations, newsletters, panel discussions, group events, farm event information booths, research summaries). The frequency of use of the electronic and print communications have been analyzed to make adjustments to increase the effectiveness and efficiency of the outreach and engagement efforts. While previous face-to-face activities were primarily limited to the immediate project area, efforts were expanded to these related channels and formats throughout West Texas. Additional efforts were made to present project-related information to those who also provide information to farmers and ranchers, most notably crop consultants and extension personnel in counties beyond the demonstration site locations.

Organizational and corporate partnerships continue to be expanded and strengthened by focusing on transferring the latest technology on monitoring of crop water-use and irrigation to aid in decision-making. This information has been packaged for delivery in hands-on workshops aimed first at crop consultants, extension agents, and producer participants, then extended to a broader range of users. We have also participated in planning and contributing presentations to various water forums, as scheduled by the High Plains UWCD and other project cooperators.

Task 7 Evapotranspiration and Validation Models

Activities in this task primarily occurred during Years 1 and 2 of Phase 2. It involved collecting in depth information on crop and grassland canopy development and evapotranspiration to further develop and validate the models and crop coefficients used in the advanced irrigation scheduling tool and other water-related applications. Real-time crop evapotranspiration data was collected from five eddy covariance flux towers established in TAWC project sites. These sites included cotton, forage sorghum, and old-world bluestem. Two additional eddy covariance systems were deployed in other fields to supplement measurements made with the current systems. In addition, remote sensing data collected as part of Task 5 will be analyzed for estimating canopy development. Finally, we will test crop water use estimated using the advanced irrigation scheduling method and compare it to observed values of crop evapotranspiration obtained from eddy covariance measurements in support of Task 5.

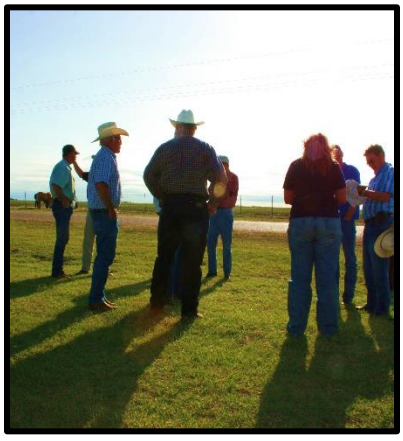
Due to retirement and change in personnel not all analysis were completed as planned.

Task 8 Integrated Crop/Forage/Livestock, Forage Seed, and Animal Production

Producer/cooperator sites that involved integrated crop/forage/livestock production, and livestock only systems were monitored annually for forage, seed, and animal productivity and use of water and other inputs to assess economics and efficiency of resource use. The specific measures of productivity varied among sites depending on the type of livestock operation. Production and inputs for hay, silage, and forage seed were documented by producers. Annual analyses involved the cost of production against the value of the product produced, and the amount of production against the amount of water and nitrogen inputs used. Information generated was incorporated into overall economic analyses of operations and was used in interpreting impacts of system diversification on water use, water saved, economic risk and profitability. Results from forage and livestock research at the Texas Tech University New Deal Farm was presented at a Field Day in 2015 and a Field Walk in 2019 to area producers to promote efficient methods of producing livestock with limited irrigation use and transfer information on the challenges of monitoring and managing water use in pastures, hay/silage crops and forage for seed production.

Task 9 Equipment, Site Instrumentation, and Data Collection (Subcontract to High Plains Underground Water Conservation District)

The High Plains Underground Water Conservation District No.1 (HPWD) acquired the instrumentation and support equipment necessary for the measurement of water pumping and application, depth to water and saturated thickness of aquifer, soil water content, and weather conditions across TAWC producer sites within the district. Equipment in good working order was moved from sites retiring from Phase 1 and reinstalled in new sites in Phase 2 of the project. Equipment in poor, unreliable, outdated condition was replaced. A mobile well flowmeter was purchased for use by TAWC personnel and used for quantifying the water yield on all cooperating producers' wells, even those not providing water to the project fields. These measurements extended the usefulness of the TAWC fields to the whole farm operation because water levels in adjacent wells are impacted by pumping in the TAWC site wells. Furthermore, additional well monitoring provided data in support of the TAWC site fields, which bolster confidence of producers in the TAWC demonstration results. Depth to water data obtained from the additional water level observation wells were added to the district's observation well database. District personnel provided maps and aerial images of field sites, well locations and any other relevant and appropriate maps to inform stakeholders and support report publications.

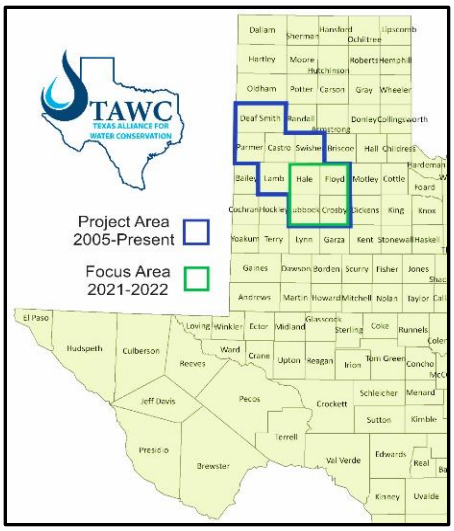


Producers attending field day for New Deal Research.

Overall Project Summary

The Texas Alliance for Water Conservation (TAWC) has been a producer-led demonstration project of cost-effective management practices, technologies, and decision-aid tools for conserving irrigation water on the Southern High Plains where producers are challenged with droughts, declining aquifer levels, and pumping restrictions. The TAWC stated mission is to conserve water for future generations by collaborating to identify and transfer those agricultural production practices and technologies which, when integrated across farms and landscapes, will reduce the depletion

of ground water and improve soil health while maintaining or improving agricultural production and economic opportunities. The overall goal is to transfer knowledge and skills to crop producers and their service providers that increase efficiency of managing irrigation and rainfall for economically valuable output while reducing risk and sustaining productivity and conservation of precious natural resources. State funded since 2004, Senate Bill 1053 appropriated $6.2M for an 8-year period (2005-2012) through the Agricultural Water Conservation Grants Program administered by the Texas Water Development Board (TWDB) (Contract No. 2005-358-014). Due to the impact achieved by TAWC, funding was extended to April of 2014, originally covering two counties (Hale and Floyd) in the Texas High Plains with 20 producers and some 4,700 project acres. In 2014, the State of Texas renewed funding (TWDB Contract No. 1413581688) for an additional $3.6M for a 5-year period (2014-2019, extended to 2021) resulting in expansion to nine-county area including Hale, Floyd, Lubbock, Crosby, Lamb, Swisher, Castro, Parmer, and Deaf Smith. This increase resulted in a maximum of 30 participating producers representing 6,177 project acres, with total TAWC producer managed area totaling over 136,000 acres.



Counties included in Project

The first 8-years established TAWC identity and developed trust among stakeholders, establishing an alliance of entities dedicated to promoting water conservation. The second phase allowed expansion of area demonstrations, and a more focused outreach and education effort of water conservation to reach a much broader audience, expanding the project scope to include soil health. TAWC was originally a cooperative venture between producers across the Southern High Plains, Texas Tech University, Texas A&M University Research and Extension, High Plains Underground Water Conservation District No. 1, USDA ARS & NRCS, and the Texas Water Development Board.

While minimal field data was collected in 2020, outreach and education efforts were continued. Thus, over the last 16 years, this project has evolved and recruited new partners including cotton, corn, and grain sorghum commodity groups. A partnership between TAWC, Plains Cotton Growers, and the Texas Tech West Texas Mesonet has resulted in a Cotton Heat Unit Calculator phone app for iOS which was integrated into the Mesonet's Weather website and made freely available to producers in managing water use and resource allocation for their cotton production systems.

A Memorandum of Understanding (MOU) was developed between Wrangler and TAWC in 2017 to promote water use efficiency among Texas cotton growers. TAWC will serve as an advisor to Wrangler's U.S. Sustainable Cotton Program and Wrangler will help raise awareness for best management practices implemented through TAWC's on-farm demonstrations. The

MOU will focus on sharing best management practices for efficient crop water use, soil health, improved water holding capacity, and retention. This will lead to fewer inputs, higher yields, and additional long-term environmental and social benefits. In 2020, TAWC also signed a MOU with NEXTT in developing the Texas Cotton Initiative (TCI). TCI is a unique program designed to provide a method for producers of West Texas cotton to receive a data collection fee per pound of cotton produced, that are certified as being sustainably grown under the U.S. Cotton Trust Protocol.

In-season field walk on participating producer farm.

TAWC has been involved in local tours by groups representing as many as twenty-eight brands from the textile and related industries including Wrangler, IKEA, Ralph Lauren, Levi Strauss, Target, and Walmart, among others. These tours provided brands with an opportunity to see cotton growing in the field, understand production challenges, and see a cotton gin firsthand. The result was a better understanding on the part of brands and producers of the value chain from field production to consumer market.

Major Accomplishments:

Irrigation Management Tools: User-friendly online calculator tools have been developed and made freely available to assist producers in planning the choice of crops and irrigation amounts to conserve water and maintain profits. The tools are a *Resource Allocation Analyzer* and an *Irrigation Scheduling Tool*, (http://www.TAWCsolutions.org). The irrigation scheduling tool is currently offline and under revision but is expected to be back online in 2022.

- Best Management Practices: TAWC has had ongoing active education and demonstration programs demonstrating more-efficient irrigation equipment, making available tools for scheduling of irrigation based on evapotranspiration, and promoting diversification of crop species which has resulted in less evaporation losses, and greater crop yield per unit of water used.

- Field-Based Testing of Emerging Technologies: As new equipment for soil moisture and crop stress sensing and irrigation system management has reached the market, TAWC has evaluated effectiveness and provided unbiased evaluations to aid producers in their purchasing decisions.

- Economic Evaluations: Profitability, costs of production, and economic efficiency have been continually evaluated through the preparation of enterprise and system budgets for all sites within the project. Producers have benefitted from site-specific and whole-farm financial analyses with respect to water use.

Producer field day with field demonstration and presentations.

- Outreach and Dissemination of Results: Field days, field walks, and workshops have been held annually to share producers' experiences with new technologies aimed at conserving water. Results have attracted wide interest among many producers and agriculture water-related stakeholders. These events have been frequently broadcast over radio to reach an even larger and more diverse audience across a wider listening area.

- Water Management Certification Program: In 2019, TAWC sponsored the development of a water management certificate program in the Department of Plant & Soil Science at Texas Tech University. The aim is to train undergraduate students for the workforce on efficient management of water for agricultural purposes, with emphasis on irrigation technologies. (https://www.depts.ttu.edu/pss/ProgramPages/agwatermanage_cert.php)

- Supplemental Grants: TAWC project members have added value to the core state funding of this project through supplemental grants supporting additional water conservation, economic analysis, field to market, and commodity partnerships. This additional funding has totaled more than $3.5M between 2005-2020. This included involvement in a 5-year, 6-state project titled "Sustaining Agriculture through Adaptive Management Resilient to a Declining Ogallala Aquifer." The $10M federal grant provided Texas Tech with $516,850 for research and outreach activities related to TAWC and expanded our visibility and impact across the Ogallala Aquifer region.

- Private Donations: Education and outreach events have been totally sponsored through private, industry, and business donations supporting speaker travel, local advertising, radio spots, leaflets, written program materials, venues, food, transportation, and fact sheets. Total donations for event funding have amounted to over $150,000 between 2005-2020. Additionally, a $25,000 gift was received from Mr. Barrett Pierce with Rio Petroleum/Farms out of Amarillo in 2020 to support ongoing TAWC efforts.

Rick Kellison, poster presentation at International Grassland Congress held in Sydney Australia, 2013.

- Presentations and Publications: From 2005 to 2020 TAWC personnel have been actively involved in outreach and education through presentations, interviews, publications, and popular press articles that have promoted water and resource conservation. These presentations have been presented both nationally and internationally.

    - National, multi-state presentations/interviews: 550+, International: 7

- Publications, Refereed: 80+, Non-refereed: 50+
- Popular press articles: 165+
- Thesis/Dissertations: 26

TAWC has participated at interstate meetings on water conservation in Colorado, Nebraska, New Mexico, Oklahoma, Kansas, Washington DC, including a leadership role in two Ogallala Water Summit conferences covering the eight states overlying the Ogallala Aquifer (2018 and 2021). TAWC has also participated and been represented in international presentations in Australia at the International Grassland Congress in 2013 and Amsterdam King Pins Convention in 2015 prompting some of the initial brand outreach and partnership efforts.

Perennial grass field demonstration for producers.

Through on-farm demonstrations of water application technologies, monitoring equipment, and tillage practices producers have been able to observe real world applications. This allows producers to determine use for these technologies and how they can fit them into individual production systems. TAWC has provided specialized training on use of a crop evapotranspiration irrigation management tool, and annually sponsors a Water College, Fall Field Day, In-season Summer Field Walks, and various other activities to provide education and demonstration of water and resource conservation. Education and outreach events are publicly broadcast over the radio reaching a much broader audience than attendees only. Utilizing farm and ranch shows, conferences, producer events, fact sheets, radio, and on-line media TAWC has reached a combined estimated impact to exceed 32,500 persons across the region.

TAWC has been involved in promoting and improving sustainable cotton standards and has participated in the Bayer, BASF e3 Cotton, BCI, Field to Market, and MyFarm programs, and more recently made a concerted effort to work with the National Cotton Council of America on the Cotton Trust Protocol.

Standard irrigation pivot modified with dragon line drip system

Support from producers, community, various government agencies, commodities, and industry has indicated the importance of TAWC as an advocate for producers and the use of technology to promote water and soil conservation. Letters of support have been received from producers, agricultural consultants, industry, National Sorghum

Producers, Plains Cotton Growers, Texas Corn Producers Board, Texas and Southwestern Cattle Raisers Association, and agricultural lobbyist such as Combest, Sell & Associates, LLC out of Washington DC, among others.

Indigo tour group of one of the TAWC producer demonstration farms.

TAWC has always sought to achieve sustainability through promoting science-based, best management practices, integrated systems, demonstrations by peer producer, and encouraging changes in attitudes toward alternative management systems. It is through the use of innovative technologies and systems promoted by education and outreach that improved and continued conservation of soil and water resources has been advanced. Only through the support of industry, community, university, state, federal and private funding sources can this effort accomplish its full mission. Projects like TAWC are vital to develop trust and provide a platform for fruitful interactions among producers, industry, and academia.

Glen Schur, TAWC producer demonstrating irrigation technologies used in farming operation.

Producer adoption has historically been slow, but with rapid drops in available irrigation water, producers now more eagerly seek information on technologies to help manage water use. TAWC has been a trusted and unbiased source of information producers turn to when determining what technologies best fit their farming operation. Outreach efforts such as TAWC's field days and Water College have grown in attendance for this reason.

Research conducted by Agricultural Communications graduate students Libby Durst and Sinclaire Dobelbower at Texas Tech University showed that the TAWC has had a strong influence on producers' adoption of soil moisture monitoring and crop water demand evaluation techniques. Their study also provided support for continued outreach and communication efforts to encourage continued adoption of water conservation behaviors:

- Durst, L., Meyers, C., Irlbeck, E., **Ritz, R**., (2016). Adoption of water conservation practices in irrigation management: An application of the theory of planned behavior in the Texas High Plains. *Proceedings of the 2016 Western Region American Association for Agricultural Education Conference*, Tucson, AZ. (September 2016)
- Dobelbower, S., Irlbeck, E., Li, N., Meyers, C. (2018). Framing the future of the Ogallala: a comparative content analysis of agricultural and mainstream media publications. Unpublished master's thesis. Texas Tech University Department of Agricultural Education & Communications.

- Durst, L., Meyers, C., Irlbeck, E.,Ritz, R. (2016). Working with water: an exploration of Texas High Plains producers' adoption of water conservation practices in irrigation management. Master Science Thesis. Texas Tech University Department of Agricultural Education & Communications.

Additional information on awards, videos, and other related information is shown in Appendix starting on page 17.

Project Water Savings:

Table 1. Amounts and percentage make-up of the sources of water contributing to total crop water demand averaged across fields and calculation of amount and depth of irrigation potentially conserved for TAWC sites in 2005-2020.

Year	Field acres	nual rainfall(inches)	Average season rainfall(50%) effective-inches)	verage total system* irrigation (inches)	erage ET crop water demand (inches)	verage crop water demand provided by rainfall (%)	p water demand providedby soil moisture (%)	Average crop water demand provided by irrigation (%)	Average crop water demand provided by total crop water(%)	Total irrigation potentially conserved all sites (acre-feet)	lexed depth(inches)
2005	3,939	14.9	5.4	9.2	22.5	25.4	na	35.9	61.3	5,134	15.6
2006	4,132	15.5	4.2	14.8	25.2	18.0	1.9	52.1	72.1	4,526	13.1
2007	4,058	27.0	8.6	11.0	18.9	50.4	na	46.7	97.1	4,130	12.2
2008	3,996	21.8	9.1	13.3	22.1	44.7	na	49.0	87.9	4,139	12.4
2009	3,861	15.1	5.4	11.5	23.6	27.0	14.7	44.8	82.2	4,365	13.6
2010	3,934	28.5	9.6	9.2	21.7	51.2	na	34.7	78.5	4,841	14.8
2011	4,033	5.3	1.5	20.9	26.7	6.8	17.6	76.6	89.2	3,475	10.3
2012	3,962	9.9	3.6	16	26.1	15.9	8.4	58.7	79.6	5,131	15.5
2013	4,552	13.2	5.2	16.2	23.5	24.7	8.7	63.8	92.6	4,099	10.8
2014	5,114	21.2	8.6	12.1	23.2	41.1	4.1	50.0	95.4	5,454	12.8
2015	3,740	30.5	7.3	11.0	25.3	32.5	17.2	42.7	92.5	4,429	14.2
2016	2,826	16.6	6.3	11.3	23.2	30.2	2.6	49.5	81.4	2,629	11.2
2017	2,656	21.5	8.0	11.3	20.5	43.0	na	51.8	94.8	1,882	8.5
2018	2,434	15.6	5.4	12.9	22.7	25.4	na	53.3	78.7	2,030	10.0
2019	1,966	19.2	5.1	10.9	25.7	21.4	na	40.0	61.4	2,106	12.9
2020	537	9.0	2.3	10.9	22.4	13.9	na	58.8	71.6	483	10.8
***Average 2005-2019**		**18.4**	**6.2**	**12.8**	**23.4**	**30.5**	**9.4**	**50.0**	**83.0**	**3,891**	**12.5**

* See TWDB 15th Annual Comprehensive Report 2005-2019 for final detailed report (www.depts.ttu.edu/tawc/resources.php). 2020 represents only a small data set and is not included in averages or detailed reports due to Covid and grant completion.

While Table 1 above includes a water savings of 483 acre-feet for 2020, this utilizes only a small dataset of project sites representing 537 acres. Limited data was due to the 2020 Covid pandemic and the closing out of TWDB Contract No. 1413581688. Data collected for 2020 represents a calculated water savings of nearly 51% based on TWDB calculations. Annual rainfall for this region is approximately 18.5 inches which represents the 15-year project average annual rainfall ranging from a low of 5.3 inches in 2011 to a high of 30.5 inches in 2015 (Table 1). Our estimated annual effective rainfall was set at 50% due to extreme rain events within years, runoff, field conditions, and evaporation. As important as the annual rainfall may be, the distribution of this rainfall is the most critical factor to crop production for our region. Soil moisture is equally an important part of available crop water but was not feasible to collect in all years of the project. However, based on the data collected, rainfall alone accounted for approximately 30% of total crop water demand within the project area, and irrigation provided 50%. In years where soil moisture was measured it accounted for an average of an additional 10% of total crop water demand. Totaling these sources would account for approximately 90% of total crop water demand being supplied from rainfall, irrigation, and soil moisture. As we are in a deficit irrigation region, it is not possible to supply 100% of total crop water demand and past research has indicated that irrigation at approximately 70% total crop water demand is sufficient for efficient crop production. Based on this information we are currently watering at approximately 50% of total crop water demand due to well limitations and conservation practices.

The average annual water savings (2005-2019, excludes limited 2020 dataset) for the project area (calculated according to TWDB specifications) are estimated at 3,891 acre-feet of total irrigation potentially conserved across all sites. These savings ranged from a low of 1,882 acre-feet in 2017 to a high of 5,454 acre-feet in 2014 (Table 1). Actual water savings are difficult to quantify due to aquifer levels being impacted by irrigation outside of our project borders. However, through the efforts of TAWC, producer awareness, new technologies, education, and demonstrations have had a significant impact on adoption of water conservation management strategies throughout this entire region for significant water savings that would otherwise have not been recognized.

Data Collection and Analysis:

TAWC has submitted yearly TWDB annual reports since 2005 summarizing the site information collected and economic analysis as well as developed various fact sheets, presentations, and videos presented by our group and our partners through our outreach and education efforts. All annual reports build on previous years report and were corrected yearly as needed. Appendices in these reports contains most of the archive data from previous years and/or summaries and as a result the most current

Cotton no-till planted into a rye stubble cover crop in an integrated crop-forage-livestock system.

Annual Report will contain the most current and correct information. TAWC is not replicated research, but real-world production under the extremes of water availability, management practices, market influences, and mother nature.

TAWC annual and summary site reports, presented posters and papers, presentations, photos and videos, outreach resources, and field talks may be found at:
https://www.depts.ttu.edu/tawc/resources.php.

Future:

The TAWC outreach, demonstrations and partner alliances established since 2005, have made a significant impact in both water and soil conservation efforts. These relationships have been vitally important to adoption and implementation of technology and best management practices. We would like to thank our partners, allies, the State of Texas, and the TWDB for its support over the last 16 years, without whose support TAWC would never have been formed.

TAWC will continue to seek state, federal, industry, and private funding to expand its efforts toward water and soil conservation. Since its creation, investment in TAWC has opened new unique lines of communication, created special alliances with industry and commodity groups, increased opportunities for developing federal funded projects, and raised producer awareness to a new level.

In 2021, TAWC was awarded a 1-year TWDB Grant. This grant is titled Water Conservation through Soil Health Improvement on the Texas High Plains (TWDB Contract No. 2103582571). This new phase of TAWC focuses on demonstration of economically viable methods of soil and crop management that conserve irrigation water and improve capture and storage of rainwater. Lack of guidelines on soil water balance and economic risks to subsequent crops has hindered adoption of cover crops. Evaluating the water use and economics of multiple cover crop species, reduced tillage, and method of termination of cover crops will enable producers to make better informed decisions.

Steer grazing alfalfa on an integrated crop-livestock system.

Specific objectives are to 1) monitor soil water balance on selected producers ' fields where minimum tillage, crop rotation, and multi-species cover crops are compared with conventional tillage and no cover crops; 2) analyze economic returns of such practices, and 3) demonstrate and disseminate results to crop producers through field visits, online presentations, and information guides. The practices can potentially conserve 300,000 acre-inches per year of irrigation water for cotton and reduce crop failure risk of rainfed cotton at modest levels of adoption.

TAWC will strive to assist, demonstrate, and provide education to producers in practices that promote conservation efforts for a strong agriculture, helping to provide a future for generations to come.

Overall Conclusions:

- TAWC has shown significant water savings of 3,891-acre feet averaged across 2005-2020.
- Significantly raised producer awareness of water and issues related to both water conservation and soil health.
- Has had a successful and unique outreach and education program that promotes water conservation through a "Producer Teaching Producer Approach".
- Been successful in producer on-farm demonstrations of those technologies that help producers conserve water and promote sustainability.
- Provided free web-based online tools that aid producers in management decisions.
- Provided unique opportunities for students to learn about water conservation.
- A model for other entities in developing similar programs.
- Provided field level "real-farm" data that has not been provided anywhere else on this scale and timeline.
- Promoted cooperation between agencies, commodity groups, universities, farmers, and communities building strong alliance to accomplish more.
- Provided a venue for dissemination of research information that can be utilized on producer farms.
- Provided a learning opportunity for researchers to focus on farmer needs and recognize applicable and needed future research.
- Built a trusted source of information that can be used by other agencies, researchers, and producers for a wide range of purposes.

Appendix

Additional Accomplishments:
TAWC has received numerous awards, been recognized through video documentaries on both the state and national level, and produced many educational videos, presentations, and webinars through an array of venues.

Awards:

- 2011 Texas Environmental Award Finalist
- 2011 TAWC Producer Glenn Schur Awarded Blue Legacy Award
- 2012 TAWC Project Awarded Blue Legacy Award
- 2013 TAWC Producer Eddie Teeter Awarded Blue Legacy Award
- 2013 AWRA Integrated Water Resources Management Award
- 2015 Texas Environmental Excellence (TEEA) Award – Agriculture Category
- 2016 National Water & Energy Conservation Award, Irrigation Association, Las Vegas Nevada
- 2018 Field to Market Farmer Spotlight- TAWC Producers Glenn Schur & Eddie Teeter
- 2019 Field to Market Farmer Spotlight - TAWC Producer Lloyd Arthur
- 2019 Outstanding Research Proposal at Association for Communication Excellence - TAWC Graduate Student Maggie Elliot
- 2021 Field to Market Spotlight Honoree – TAWC Management Team Member Donna McCallister
- 2021 Field to Market Farmer Spotlight Honoree – TAWC Producer Barry Evans
- 2021 Field to Market Farmer of the Year – TAWC Producer Barry Evans

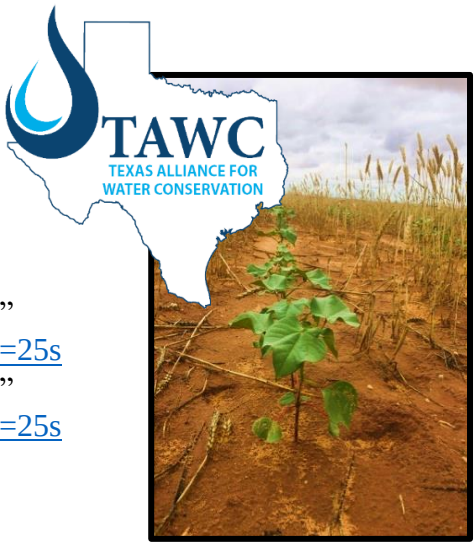
TAWC administration members accepting the Blue Legacy Award 2012.

USDA-SARE Commissioned Web Video Documentaries:

- 2012 - "The Ogallala Aquifer of the Texas High Plains: A Race Against Time" http://www.southernsare.org/Educational-Resources/SARE-Project-Products/Southern-SARE-Multimedia/Water-Conservation-on-the-High-Plains
- 2016 – "Water Conservation on the High Plains". Picador Creative, Texas Tech University. http://www.southernsare.org/Educational-Resources/Multimedia/Videos-From-the-Field/The-Ogallala-Aquifer-of-the-Texas-High-Plains-A-Race-Against-Time

Texas Tech University Videos

- 2016 – "Texas Alliance for Water Conservation" https://www.youtube.com/watch?v=X5vowOnIEf0
- 2019 – "Texas Alliance for Water Conservation" https://www.youtube.com/watch?v=6yfNmtsrgPQ
- 2020 – "Texas Alliance for Water Conservation, Texas Tech University – Rudy Ritz" https://www.youtube.com/watch?v=6vc1qeFV5V8
- 2020 – "Texas Tech Community Partners – Lloyd Arthur" https://www.youtube.com/watch?v=nJpgmYMmxMk&t=25s
- 2020 – "Texas Tech Community Partners – Lloyd Arthur" https://www.youtube.com/watch?v=nJpgmYMmxMk&t=25s
- 2021 - Mutually Beneficial Partnerships for Resilient Communities – University Outreach & Engagement" https://www.youtube.com/watch?v=a3NCU169vyc



Cotton planted into rye/wheat cover

Other Videos:

- 2015 Texas Environmental Excellence Award Winner for Agriculture Category: Texas Alliance for Water Conservation - YouTube

Webinars:

- 2017 - Boosting producer learning, exchange and adoption of water use efficient technologies: Strategies from the High Plains/Ogallala region. Climate Learning Network/ANREP Community Science Initiative. Nov. 2, 2017. www.climatewebinars.net/webinars.
- 2020 - Alfalfa in low-irrigation and rainfed grass-based pastures in West Texas. Rancher's Thursday Lunchtime Series–Alfalfa Management. Oklahoma State University Extension Service. Aug. 13. https://www.youtube.com/watch?v=iJqa79QQJC4.
- 2020 - Soil biological health as affected by cover crops and forages for this region. TAWC Field Day online webinar. 8 Sept. https://www.youtube.com/watch?v=xCloyrp5Gdk
- 2020 - Improving pastures with alfalfa. Texas Alliance for Water Conservation (TAWC). 17 September. http://www.depts.ttu.edu/tawc/resources.php

Websites:

- http://depts.ttu.edu/tawc
- http://www.tawcsolutions.org/
- https://www.youtube.com/user/TTUTAWC/videos
- https://www.youtube.com/user/TTUTAWC/videos