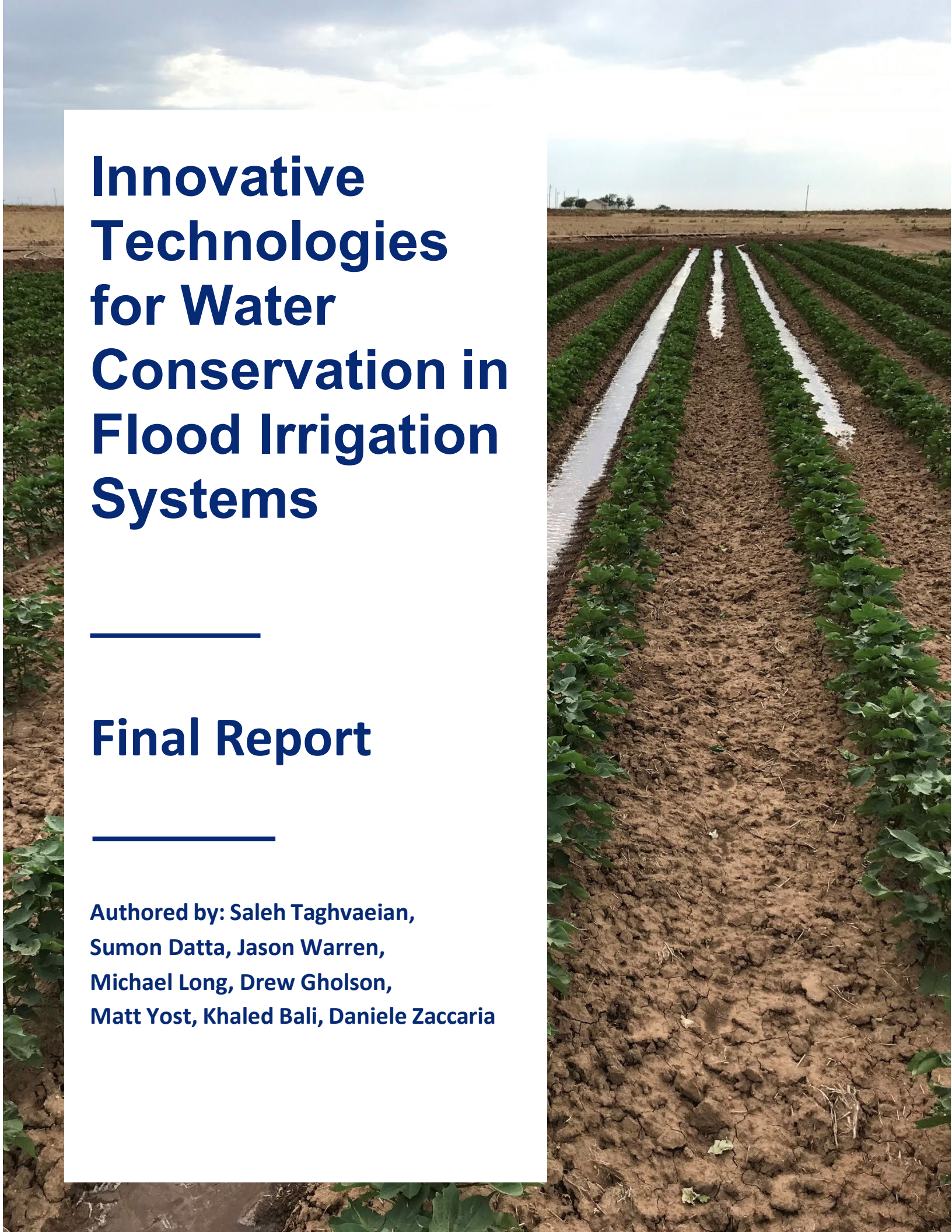

Innovative Technologies for Water Conservation in Flood Irrigation Systems

Final Report

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Summary

Grantee Name: Oklahoma State University
Project Title: Innovative Technologies for Water Conservation in Flood Irrigation Systems
Agreement Number: NR203A750008G007
Project Start Date: April 24, 2020
Project End Date: April 15, 2023

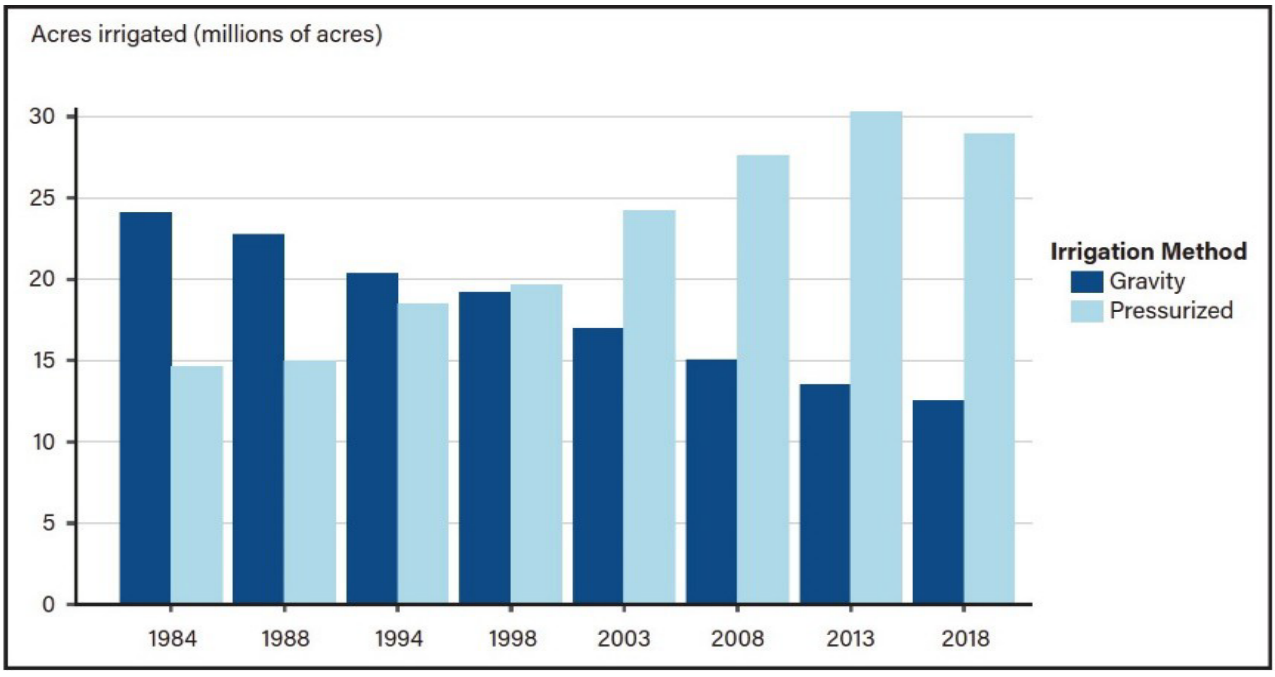
The goal of this project was to evaluate, demonstrate, and transfer innovative technologies that can result in water conservation in flood systems by conducting coordinated extension activities among partners from southern to western U.S. The perception of producers and the sociocultural factors that influence their acceptance of conservation technologies were also evaluated. The specific objectives were: i) to evaluate the social dimensions of adopting conservation technologies; and, to evaluate and transfer effective and affordable conservation technologies and management practices related to ii) water delivery (e.g. canal automation); iii) water use (e.g. sensor-based irrigation scheduling) and iv) water removal (e.g., tailwater recovery and reuse) components of flood systems.

Left: Water delivered by siphon tubes to a cotton field in Oklahoma.

Left: Water delivered by polypipe to a corn field in Mississippi.

Background

Flood (a.k.a. gravity or surface) irrigation has been a main method of water application to agricultural and horticultural crops since the beginning of irrigation several thousand years ago. Although more advanced irrigation systems such as sprinkler irrigation and more recently drip irrigation with potentially higher efficiencies have been developed and adopted in the past several decades, flood irrigation is still practiced in many irrigated farms across the U.S. According to the Farm and Ranch Irrigation Survey, flood irrigation accounts for one-third of all irrigated lands and 43% of the total irrigation water applications in the U.S. However, only 10% of federal financial assistance for irrigation best management practices has been dedicated to flood irrigation. Although conversion from flood to sprinkler and drip systems has happened in many regions and is still in progress, many irrigated acres will remain under flood systems for a combination of hydrologic, agricultural, social, and economic reasons. Hence, it is important to investigate and promote new and innovative technologies that can lead to water conservation in flood systems.

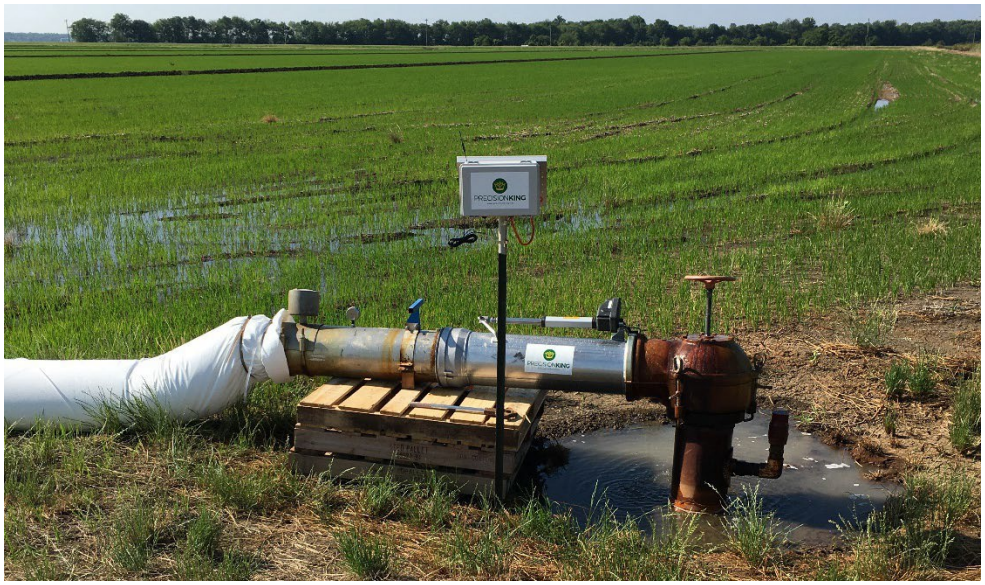


Irrigated farmland area in gravity and pressurized systems, 17 Western States, 1984–2018.

Source: Hrozencik, R. Aaron and Marcel Aillery. December 2021. Trends in U.S. Irrigated Agriculture: Increasing Resilience Under Water Supply Scarcity, EIB-229, U.S. Department of Agriculture, Economic Research Service.

Methods

A wide range of technologies were evaluated and transferred by establishing demonstration sites and disseminating the results using conventional and innovative outreach approaches. In Mississippi, furrow irrigation was automated using soil moisture sensors, pump controllers, and automated actuated valves to allow the remote start of the irrigation set and a seamless transition from one set to the next by opening and closing valves through a preset length of time. Total water use and yield were recorded for automated fields and nearby conventionally-irrigated fields to allow for comparisons. In Oklahoma, soil moisture probes and canopy temperature sensors were installed at cotton fields irrigated with every and alternate furrows. The participating growers received training on how to use the information to manage their irrigation events at a time when their water allocation was severely limited due to droughts.



Demonstration of irrigation valves and flowmeters at a site in Mississippi.

In Utah, three demonstration sites were established in Corinne, Garland, and Delta. At all sites, soil moisture sensors and irrigation advancement sensors were demonstrated. In addition to the three mentioned sites, three surface irrigation systems (lay-flat tubing with cut discharge holes for furrows, siphon tubes, and buried PVC head pipe with removable PVC pipe risers) were evaluated in West

Weber and Bear River City, Utah. All the diversions and runoff were measured with continuous recording flow depth and velocity sensors in piped sections of delivery system and runoff. Soil moisture data was obtained with 10 soil moisture sensors located in the top, middle and bottom of the fields. Yield samples were taken at 9 locations in each field.

Left: An automated irrigation valve opens and begins irrigating an alfalfa crop in Utah.

Right: Solar-powered irrigation advance sensors (Wet Stake) were tested and demonstrated.

In California, demonstration sites were established at UC Kearney Agricultural Research and Extension Center, KARE (alfalfa on border irrigation), Parlier, UC Desert Research and Extension Center, DREC (furrow irrigation), a commercial site in Buttonwillow (alfalfa border irrigation), and two commercial grass grazing fields in Big Valley area near Adin (border irrigation). Measurements of flow rate, slope, and advance rate during irrigation events as well as drone flights to estimate advance rate were conducted at all locations. In addition, the WinSRFR model was to evaluate irrigation events. At three of the sites, infiltration rates were measured to help in designing a surface irrigation system that could be used to increase the efficiency of recharge by maximizing the deep percolation component and elimination runoff.

Results

This project demonstrated the application of several conservation technologies in flood irrigation systems under variable agro-hydrological conditions. Many lessons were learned regarding the best management practices of these technologies. The findings were communicated to stakeholders through extension events, field days, presentations, and fact sheets. Some of the major findings are summarized below.

"Advanced sensing technologies could be used effectively in improving flood irrigation uniformity and efficiency, but the proper use of sensors and achieving a reasonable return on investment requires technical and financial support offered by university personnel and state and federal agencies. The sensors demonstrated in this project included several soil moisture sensors and probes, canopy temperature sensors, and water advance sensors."

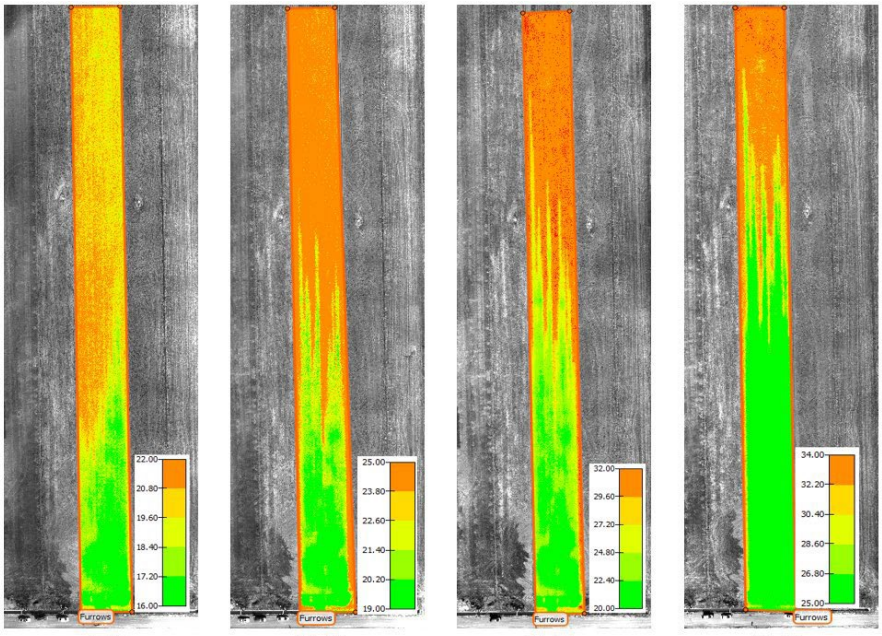
"Surge irrigation increased irrigation and yield uniformity. In addition, about 25% less diverted water was used to achieve similar and/or better yields than without surge irrigation."

"Flood irrigation systems could be utilized for groundwater recharge in California with little to no impact on alfalfa yields. Alfalfa fields could be used to recharge as much as 60-70" of water into groundwater aquifer during the winter period. Enough water to meet the seasonal water requirements of alfalfa or major orchard crops such as almond in the Central Valley of California."

Arial view of furrow irrigated field irrigated by Rubicon Water Automated gate at UC Desert Research and Extension Center, Holtville, CA on 2/16/2022.

2/16/2022 Thermal Images

with color scale



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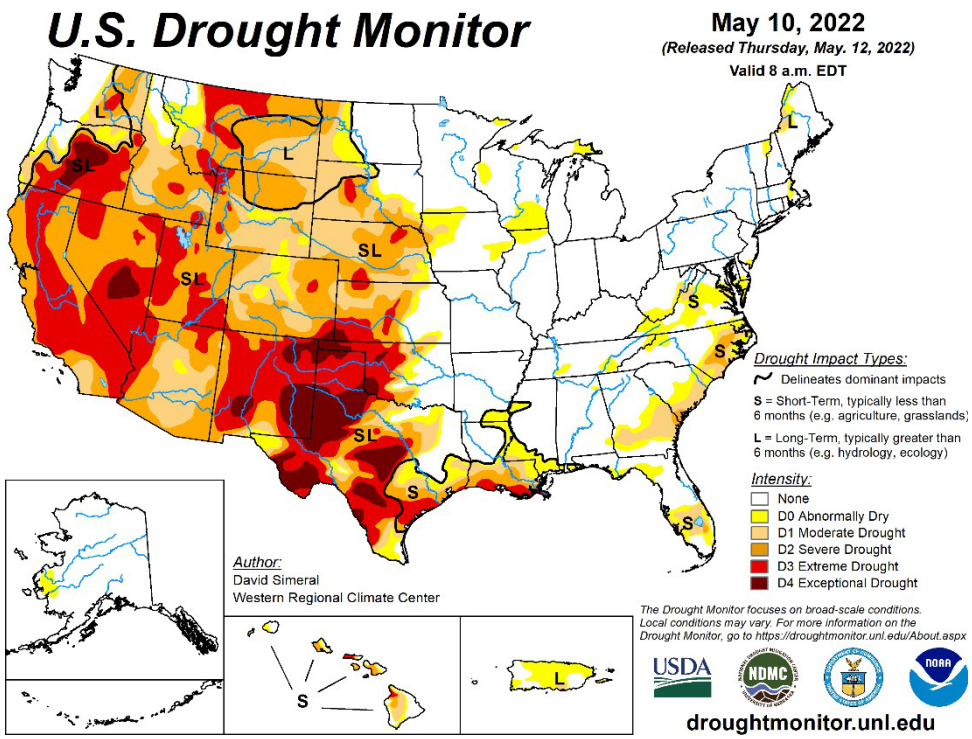
Water advance rates at the same field at different times of the day using thermal imaging.

Challenges

Two main challenges limited our ability to reach and exceed the intended level of stakeholder engagement in this project: severe drought and COVID pandemic. Severe droughts negatively impacted the availability of surface water resources, which are the main sources of irrigation water for flood systems especially in California, Utah, and Oklahoma. In Oklahoma, for instance, the water levels in the lake that supplies water to the Lugert-Altus irrigation district did not reach diversion elevation by the beginning of the irrigation season during the entire project period.

The beginning of this project coincided with the onset of the COVID pandemic, which resulted in cancelation of all field days and extension events. Virtual events that were eventually devised were not as popular as in-person events. By the second year of the project, in-person meetings following strict protocols were allowed to take place in some states and the team was able to better communicate project results to stakeholders.

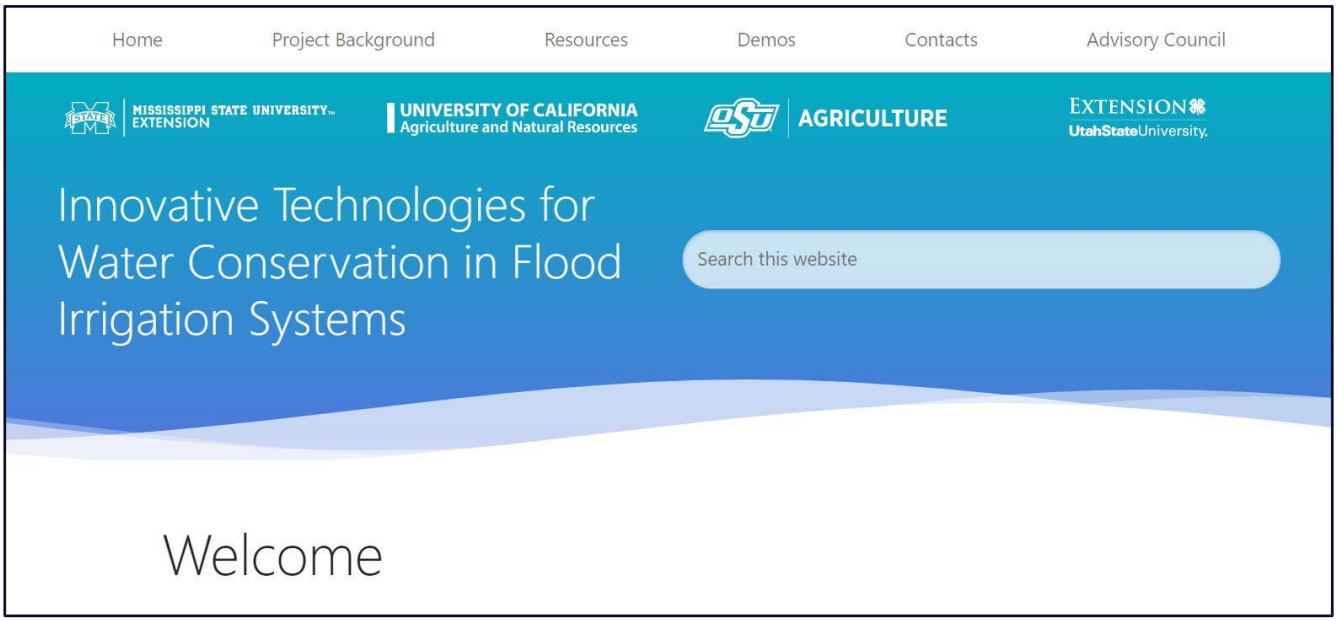


The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.

Outputs

The project resulted in a wide range of outputs to meet the demand of producers with variable levels of knowledge and experience across the project area. The outputs included:

- One website dedicated to flood irrigation information and fact sheets (http://surfaceirrigation.extension.msstate.edu/);
- More than 30 demonstration sites in each year of the project from Mississippi to California; and,
- More than 70 in-person and/or virtual presentations at field days, showcases, and other extension events.



Next steps

The project team highly recommends continued financial and technical support for projects focused on flood irrigation, warranted by two factors:

1) a considerable portion of irrigated area in the US will remain under flood irrigation in the foreseeable future due to a number of reasons; and,
2) precise irrigation management for water conservation tends to be more challenging in flood irrigation systems.

The project identified the following areas that could benefit from additional applied research and demonstration:

1) sensor-based scheduling of flood irrigation considering the limitations imposed by water source, water distribution network, and water suppliers,
2) in-situ and remote sensing technologies for evaluating the uniformity of water application in flood irrigation systems,
3) use of flood irrigation systems for artificial groundwater recharge, especially where infiltration data based on soil maps are not accurate, and
4) implementation of automation technologies such as surge valves and pump/well remote control.

Specific recommendations for NRCS based on the interactions with collaborating producers and the advisory board include:

1) regular assessment and updating of the cost of different conservation technologies in flood irrigation to ensure available funding matches the cost of implementing conservation measures; and,
2) ranking flood irrigation equal to pressurized systems, especially in parts of the country where there is a clear advantage in using flood irrigation.