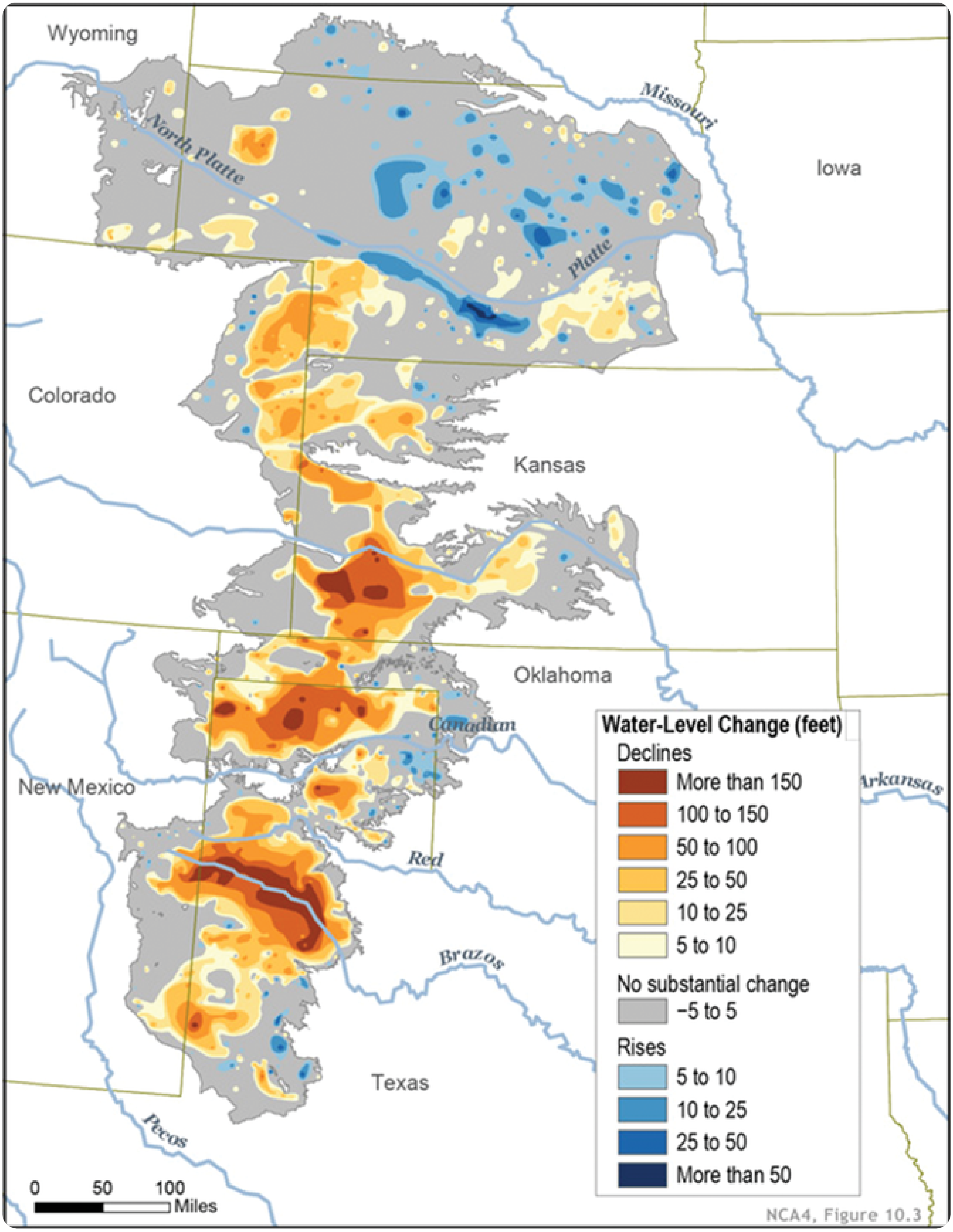
# How Do I Conserve Groundwater While Irrigating?

January 1, 2024


Wyoming
North Platte
Missouri
Iowa
Platte
Colorado
Kansas
Oklahoma
Canadian
New Mexico
Arkansas
Red
Brazos
Texas
Pecos
0 50 100
Miles
Water-Level Change (feet)
Declines
More than 150
100 to 150
50 to 100
25 to 50
10 to 25
5 to 10
No substantial change
−5 to 5
Rises
5 to 10
10 to 25
25 to 50
More than 50
NCA4, Figure 10.3

*Changes totheOgallalaAquifer since 2015,mappedby color.Declining levels appear in red and orange, and rising water levels appear in blue. Gray areas showed no significant change. The market value of agricultural products produced in the Ogallala region total $35 billion in 2007, and climate change and water overuse threaten the viability ofthose systems. Image courtesy of Climate.gov.*

---

**The short answer:** Groundwater is a finite resource. Conserving water while irrigating comes down to matching water applications to crop water requirements, effectively utilizing precipitation, preventing water from evaporating, applying water when it's needed most, including lower water-use crops in your rotations, and exploring deficit irrigation strategies.

- **Groundwater**—water stored in the pores and fractures in rock, gravel, and sand—makes up about 39% of the water used for agriculture in the U.S.
- **If groundwater** is available in a large enough amount that you can pump it from below the earth's surface, it's known as an aquifer. Aquifers like the Ogallala are critical sources of irrigation water for agriculture in areas where rainfall isn't enough to grow crops.
- **Groundwater pumping** is outpacing groundwater recharging, meaning that water sources below the surface of the earth are quickly depleting.

**Break it down:** When it comes to agriculture, there are five ways that growers can help conserve groundwater.

**1. Apply water when crops need it most**, being mindful of soil water capacity.

- **Soil water capacity** is the amount of water that a field's soil can hold for plant use. Field capacity refers to the total amount of water a field can hold before drainage occurs—it's considering soil water capacity across the entire field. The soil water capacity of every field is influenced by its soil texture, soil organic matter (SOM), and compaction. You can't change your soil's texture, but there are lots of ways to improve SOM, prevent compaction, or improve compacted soils.
- **All crops have critical** periods in which they need the most water to grow and produce a crop. Understand these critical periods, and portion water uses to match.
- **Once you know your soil water capacity** and critical periods for irrigation, take care to only apply water when it is most needed. If rain is in the forecast, wait for this free water and do not oversaturate the soil beyond field capacity—water lost to drainage and runoff is water (and nutrients) that plants can't use.
- **Use irrigation-scheduling tools** whether it is looking at the soil (i.e., soil sensors) and/or weather (i.e., ET-based scheduling) and/or crop (e.g., thermal, dendrometer) to know when to apply that water.


*Irrigation systems listed clockwise from most evaporative water losses to least beginning with above canopy irrigation. All photos courtesy of the Irrigation Team, K-State Research-Extension.*

2. **Improve irrigation efficiency.** Make the most of your groundwater by preventing it from evaporating. Any irrigation improvement that gets more water to the roots of the plant and prevents evaporation and runoff will increase water use efficiency, helping protect a precious and finite resource.

- **In-canopy or near-surface** irrigation systems prevent evaporation by decreasing the amount of water flying through the air, landing on the plant canopy, or landing outside of the field when it's windy. See the table (below) for a comparison of common irrigation systems and their impact on evaporation.
- **Sub-surface drip irrigation** is even more efficient than near-surface or in-canopy irrigation since all of the supplied water is delivered directly to plant roots. But it's

also an expensive transition to make and not suitable for all crops. When looking to increase water use efficiency, balancing the cost to change to new irrigation systems with your needs on farm can mean that’s not the best option for you.

- **For example**, when maintaining or updating your irrigation system (as the NRCS recommends you do every 10 years), explore options that bring sprinklers or nozzle heads closer or into the canopy.

3. **Explore deficit irrigation**. Deficit irrigation is a technique in which farmers increase the productivity of water, making water use more efficient.

- **Deficit irrigation** balances trade-offs: rather than aiming for the greatest possible yield, deficit irrigation seeks to grow as much as possible with limited water.
- **In practice**, deficit irrigation means that farmers are supplying less water than plants lose through evapotranspiration and the soil loses through evaporation. When paired with practice  like conservation tillage, it can help maximize water use efficiency.
- **Many plants can tolerate** getting less water than needed, and some plants even adjust to these drier conditions without significant yield reduction.

4. **Replace high water-use crops** with lower water-use crops that work better under deficit

irrigation.

- **Substituting sorghum** for corn silage can help extract water from deeper in the soil profile and produce greater yield than corn with much higher water use. The forage quality of higher- yielding sorghum and its residue can be a good substitute for high-water use corn.

- **Pearl millet** is another great low water-use grain option that is highly drought tolerant and makes a good livestock feed.
- **Triticale, cotton, sunflower,** and other suitable crops may use less water or have different timing for their peak water use compared with your traditional crop rotation. These are good options for areas with limited water supply. Plus, triticale makes a great high-biomass, low- water-use harvested forage for livestock.

| IRRIGATION TYPE | DESCRIPTION | EVAPORATION IMPACT | BENEFITS | DRAWBACKS | COST TO INSTALL* |
| --- | --- | --- | --- | --- | --- |
| ***Above-canopy*** | Traditional center pivot or lateral-move irrigation sprinklers installed above the plant canopy (top of pivot or near truss rod). | Highest evaporation losses of all systems, with evaporation during air travel, drift from field, from the plant canopy, the soil, or runoff from field. | • Uniform application across the field.<br>• Reduced potential for runoff.<br>• Can be used in fields with steeper topography.<br>• Easier to spot clogged or problematic nozzles. | • Operating pressure 25 psi or higher.<br>• Higher operating pressures correspond to greater costs in pumping water.<br>• Up to 40% wind drift and evaporation losses. | Quarter mile center pivot: $556.00 per acre.<br>Half mile center pivot: $338.00 per acre. |
| ***Near-canopy or mid-elevation spray application (MESA)*** | Modifies a center pivot with longer sprinkler arms that reach near the plant canopy. | 15% lower evaporation loss compared to high-pressure systems. | • Less evaporative losses when compared to above-canopy spray. | • Costs from operating pressure and water pumping.<br>• Wind drift and canopy evaporation losses. | Quarter mile center pivot: $556.00 per acre.<br>Half mile center pivot: $338.00 per acre. |
| ***In-canopy*** | Similar to above and near-canopy, but the sprinkler heads are within the plant canopy (about 4-ft above ground). | Lower evaporation than near-canopy, mid-elevation, and near-canopy systems since smaller portion of canopy is wetted. | • Less evaporative losses when compared to above-canopy spray.<br>• Often lower pressure systems that reduce costs associated with groundwater pumping. | • Costs from operating pressure and water pumping.<br>• Greater challenges for non-uniform applications that can result in runoff, erosion, and deep drainage losses. | Quarter mile center pivot: $556.00 per acre.<br>Half mile center pivot: $338.00 per acre.<br>Additional cost for longer drop height of sprinkler heads. |
| ***Low-elevation spray application (LESA)*** | Modifies a traditional center pivot or linear-move irrigation system to use suspended sprinklers or spray heads very near the soil surface (about 2-ft above ground). | Decreased evaporation and 97% irrigation efficiency. | • Operating pressure of about 15 psi, with a very high application rate and reduced evaporation.<br>• Applies water more uniformly than LEPA systems, giving water more time to infiltrate with soil. | • Sprinkler heads may drag through crops or skip rows if caught in one place.<br>• Can be a challenge to operate in undulating fields.<br>• Sprinkler heads must be placed closer together, with longer drops, which may cost more to buy and install.<br>• May not be used to incorporate foliar chemicals. | Quarter mile center pivot: $556.00 per acre.<br>Half mile center pivot: $338.00 per acre.<br>Additional cost for longer drop height of sprinkler heads. |
| ***Low-energy precision application (LEPA)*** | A system that modifies typical sprinklers on center pivots to drag hose socks along furrow dikes. It minimizes evaporation and wind losses and operates at much lower pressure, making it highly efficient. | Decreased evaporation and 97% irrigation efficiency. | • 16% yield increase compared to above canopy for irrigation treatments below 50% of full irrigation.<br>• Uses much less pressure (6-10 psi pressure regulators) to operate compared to traditional irrigation, saving on energy costs.<br>• Works best on low-profile crops like cotton or peanuts. | • Applies water to soil in much less time, sometimes causing ponding or runoff.<br>• Growers may need to use techniques to prevent runoff, including additional furrow dikes or drag socks to limit erosion, or speeding up the irrigation system to apply smaller application depths per pass.<br>• Only applicable for flat fields.<br>• Need to plant in circular pattern. | LESA systems can be easily converted to LEPA by replacing spray nozzles with a drag sock or hose adapter and adding furrow dikes or furrows (which, alone, work well for flat and sandier fields). |
| ***Mobile-drip irrigation (MDI)*** | Combines efficiency of sub-surface drip irrigation and versatility of center pivot systems in one unit. | 35% lower soil evaporation compared to in-canopy spray nozzles. | • Reduced wheel-track rutting and ease of fertigation compared to low-elevation spray application.<br>• In high water-use crops like corn, producers may recover the costs of conversion from LESA to MDI in 2-5 years for low to medium conversion costs based on water efficiency savings with an assumed constant yield.<br>• Can be used in slightly undulating fields where LEPA is not viable. | • Provides many of the benefits of SDI with lower installation costs.<br>• Drip hoses dragging on the ground behind the center pivot may interfere with field operations.<br>• Highly suggested to plant in circular pattern to optimize its efficiency. | If converting from LESA, costs range from $250-280 per acre. |
| ***Sub-surface drip irrigation (SDI)*** | SDI uses buried drip tubes or drip tape to supply water to crops using low pressures and high water-use efficiency. | Decreases corn water use by 17-18% while increasing yield 0-20% in the Texas High Plains by reducing early-season evaporation. | • Warmer soil temperatures earlier in the season, which reduced evaporation and improved root development and early crop growth.<br>• Best suited for automation, fertigation and variable rate irrigation.<br>• Can irrigate irregularly shaped and undulating fields. | • Management and maintenance of the system has a steep learning curve for starters.<br>• Highest initial investment cost. | $1,200+ per acre. |

*Cost, benefit, and precipitation loss comparison of common irrigation systems. Cost estimates for all irrigation systems but MDI sourced from “Economics of Irrigation” by Texas A&M AgriLife Extension: https://itc.tamu.edu/files/2019/12/B-6113.pdf. MDI cost from O’Shaugh- nessy & Colaizzi, 2017: https://doi.org/10.3390/agronomy7040068.*

5. **Explore new innovations** in automated sprinkler systems, precision application, and soil water monitoring.

- **Precision irrigation** and sprinkler automation systems use GPS location guidance systems and soil and crop mapping to help apply water when and where it's needed.
- **These systems** account for the variations across a field—some areas may dry out faster than others, leaving less water in the soil. Coupling precision irrigation with the other techniques listed above could boost water use efficiency even further.
- **Tools that monitor soil water potential** are another innovative technology that can help farmers understand what's going on in their fields. Though traditional soil moisture sensors can be helpful for understanding whether a soil is wet or not, measuring soil water potential can be a great way to understand how the wetness of the soil impacts plant available water.
- **While exploring new technologies**, don't forget to maintain your existing equipment. There are minor adjustments that may be keeping your equipment from being the most efficient or may be costing you more (e.g., pumping energy cost).

**In short**, groundwater is a finite resource. With unpredictable weather patterns and a changing climate, finding ways to make the most of our water resources is imperative. Even small changes to your irrigation regime can make a big difference when it comes to getting water to plants when they need it the most.

Decode 6

DECODING CARBON AND ECOSYSTEM SERVICES

This article comes to you from Decode 6 (https://decode6.org/), bringing clarity to carbon and ecosystem service markets through transparent, un-biased, and freely accessible educational content for all. New articles, videos, podcast episodes, and explainers are rolling out on the site all the time.

This article was written by DJ May and reviewed by Jean Steiner (USDA-ARS) and Jonathan Aguilar (K-State Research and Extension). It was adapted from the review article, "Policy Technology, and Management Options for Water Conservation in the Ogallala Aquifer in Kansas, USA," published Dec. 2, 2021 in the journal Water.''

---