Is Irrigated Agriculture Sustainable?
The Battle to Counteract Salinity

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Irrigated agriculture accounts for billions of dollars in the U.S. economy. According to 2002 data, agricultural production in ten counties exceeded $1 billion or more (see table, next page). All ten of these counties are in the western United States; nine are in California and the tenth is in north-central Colorado. All of the counties have annual evaporative demands greater than rainfall, which means that irrigation is required for optimum plant growth and survival. Thus the availability of water for irrigation is critical to meet the food and fiber needs of the United States.

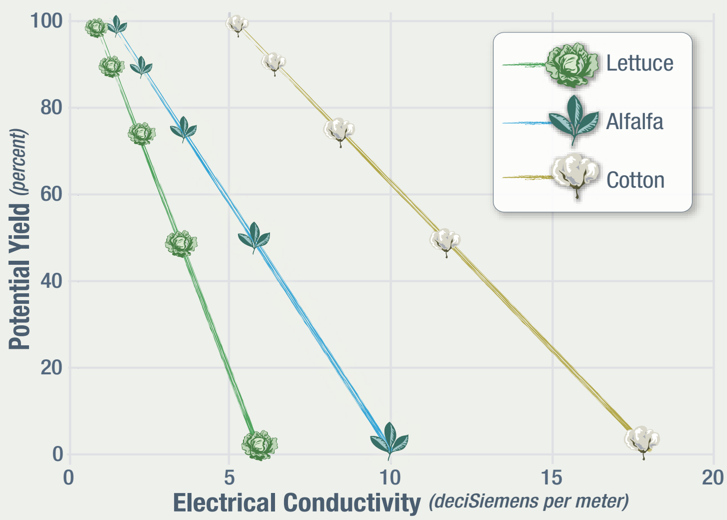
In the semi-arid Southwest, virtually all agricultural production depends on irrigation. In central and western Arizona, much of the water used for irrigation comes from surface water sources including the Colorado, Salt, Verde, and Gila rivers. Over the past five to ten years these projects have struggled to supply adequate water due to decreasing water supplies and a persistent drought over much of the West. A compounding problem, faced not only by Arizona, is that as lake and reservoir levels fall, the salinity of the remaining water increases. Increased salinity in irrigation water increases the osmotic potential in the root zone and can lead to a reduction in yield because plants are unable to extract sufficient moisture from the soil to meet evaporative demands. Excess irrigation is then needed to leach the excess salts below the root zone. Thus increases in salinity result in increased water demand, placing a further strain on water supplies during periods of drought.

> *For irrigated agriculture to be sustainable, ... water supplies must not merely meet the evaporative demands of the crops grown: up to twice that amount of water is required to prevent salt accumulation in the root zone.*

Different Crops for Different Salts?

The link between irrigation, salinity, and productivity has been recognized for nearly 150 years and a considerable research effort has been undertaken to prevent loss of productive irrigated lands to salinization. One effort that has helped maintain productivity while reducing the quantity of water needed for irrigation is determining crop response to salinity. The graph at right shows the response to salinity of three important irrigated crops grown in the arid Southwest: lettuce, alfalfa, and cotton. The graph shows the normalized potential yield response to increasing salinity and demonstrates that individual crops have a threshold for reduced yield due to salinity. For example, at the salinity level at which cotton just begins to exhibit yield reduction, lettuce yield has dropped to near zero. Thus, the selection of crop type is very important when managing the salinity of irrigation water.

Over the past ten years, the salinity of Salt River Project water delivered for irrigation in central Arizona has averaged 0.5 to 1.4 deciSiemens per meter (dS/m), depending on the time of year and source of the water being delivered. Colorado River water delivered to Nevada, Arizona, and California averaged 0.95 dS/m over the same time period. Agricultural production along the Colorado River near Yuma depends on a successful winter lettuce crop. Because lettuce has a salinity threshold value of 0.90 dS/m, if salinity levels rise significantly in the Colorado River, area crop yields will be significantly reduced. On the other hand, cotton has a salinity threshold of 5.1 dS/m and shows only a 25 percent reduction in yield at a salinity of 8.4 dS/m. If the increase in salinity seen in the Southwest continues, it may mean a shift in cropping patterns and potential economic impacts on agricultural production throughout the region.



The effects of salinity on crop yield.

Use of Reclaimed Water for Irrigation

Urban water needs put additional pressure on irrigated agriculture. Increasingly, urban water users are purchasing water from agriculture and replacing it with water of lesser quality. In the Phoenix metropolitan area, Buckeye Irrigation District uses reclaimed municipal sewage from a city sewer treatment plant for irrigation. Water passing through municipal treatment, distribution, and reclamation facilities of the Phoenix metropolitan area can increase salinity by up to 50 percent. Salt loads in waste water increase both in concentration (due to evaporative processes) and total mass (due to importation of salts via processes such as water softeners). This increase in salt load to the waste water treatment plants places a greater strain on the organisms used for treatment and can potentially preclude the use of reclaimed water for the irrigation of salt-sensitive crops.

Rank	County (State)	Market Value ($1,000)
1	Fresno (California)	2,759,421
2	Tulare (California)	2,338,577
3	Monterey (California)	2,190,121
4	Kern (California)	2,058,705
5	Stanislaus (California)	1,228,607
6	San Joaquin (California)	1,222,454
7	Weld (Colorado)	1,127,854
8	Imperial (California)	1,043,279
9	Ventura (California)	1,018,864
10	Riverside (California)	1,008,273

Agricultural production of the top ten U.S. counties, 2002. Source: U.S. Department of Agriculture.

Lessons from History

The costs of not addressing the salinity issue will have far-reaching impacts. Throughout history, only the Nile River Valley in Egypt has sustained a civilization dependent on irrigation. Since irrigation first began along the Nile River, annual floods that inundate the land have not only provided fresh nutrients but also carried away the salts imported by irrigation water from the previous season. Other civilizations in both the old and new worlds that depended on irrigation ultimately collapsed due to salinization and the loss of arable lands caused by irrigation and inadequate leaching of salts from the root zone.

An example of the catastrophic effects of salinization due to irrigation without leaching can be seen in the archaeological record of the Hohokam people of central Arizona. Land that is now irrigated with water from the Salt River and Central Arizona projects was first irrigated by the Hohokam from 200 B.C. to 1450 A.D. using a network of small control structures and canals. Current thought is that the Hohokam finally faded as a culture due to salinization impacts and subsequent insufficient food production.

Growing Needs and Developing Technologies

Today the production of sufficient food and fiber to meet U.S. needs is dependent on the use of irrigation to maximize yields. For irrigated agriculture to be sustainable, however, water supplies must not merely meet the evaporative demands of the crops grown: up to twice that amount of water is required to prevent salt accumulation in the root zone. As population in the southwestern United States grows, so grows the competition for a limited water supply, and the water needed for maintaining salt balance is also likely to be a prime candidate for reallocation.

Present technologies such as micro-irrigation, crop selection, and plant breeding are providing a way for irrigated agricultural production to keep pace with needs while using less water, however there are theoretical limits to how much water can be saved using these techniques. Micro-irrigation is currently being used not to maintain salt balance in a field but to maintain the salt balance in the root zone of individual plants. This allows for much less water use but causes salts to accumulate in the soil, increasing the complexity of managing and irrigating the crop. In the San Joaquin Valley of California, efficient use of land and water is maximized by growing crops with varying salt tolerances in sequence and by maintaining all imported salts within the boundaries of individual farms. Plant breeders are also looking for ways to select for crops that can tolerate higher salinity levels without a significant loss in productivity or quality.

Lacking a natural resource that purges itself of salinity such as the mighty and reliably flooding Nile, we in the Southwest must remain determined to avoid the fate of the Hohokam and continue to seek ways to improve irrigation to secure a sustainable agricultural future.

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