SLIDES: Food Production: Technical Challenges in Agricultural Water Conservation

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Food Production

Technical Challenges In Agricultural Water Conservation

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Getches-Wilkinson Center
Dr. Perry Cabot, Colorado State University
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Is it impossible to “conserve” water in agriculture in any way other than retiring land?

Does moving to more efficient systems decrease diversions, but also decrease runoff, resulting in no net change in consumption?
Two basic strategies to achieve “forgone diversion”

Conservation and Efficiency
Conservation is about doing less with less water diverted.

Municipalities conserve when residents use less water in their day-to-day activities.

Reduced irrigation for lawns.

Green lawns grow property values, so in a sense the “yield” may go down and the resident could suffer a real economic loss.
Conservation in agriculture and food production has real financial impact.

If food producers cut back on irrigation, there can be economic shortfalls.
Example – yield vs ET relationship for alfalfa

\[ y = 0.177 \times \]

or 5.6 in/ton

Water Bank Phase IIB Research – Alfalfa Sites

No irrigation after 2nd cutting – yield losses
2013: 0-54%
2014: 4-39%

No irrigation after 1st cutting – yield losses
2013: 42-71%
2014: 55-82%

No irrigation all season
2013: 77% yield loss

Photo taken 7/29/2013 by Lyndsay Jones

Stop after second cutting
Stop after first cutting
Conservation by “split-season” irrigation of perennials

- Water that would have left the system (CU) now stays in the system as conserved consumptive use (CU) water through forgone diversion.
- Return flows partially diminished through forgone diversion—some saved water also remains in the system.
- For a given acre of alfalfa, you would expect a yield reduction.
Innovative Deficit Irrigation - alfalfa

\[ y = 0.0008x^2 - 0.0169x + 0.1863 \]
\[ R^2 = 0.9029 \]

\[ y = -0.1912x^2 + 3.1543x + 3.9386 \]
\[ R^2 = 0.9878 \]
Conservation by row-crop rotational fallowing

- Positive impacts from fallowing include **breaking disease cycles**, improvement of organic matter, increases in soil fertility.
- Healthy fallow periods can even foster **yield improvements** and allow farmers to switch to organic.
Are there technical challenges in agricultural water conservation?

Sure, **but fallowing has been practiced for decades**, so these challenges can be addressed (cover cropping, weed management, soil health).
Efficiency is about doing the same (or more) with less water diverted.

“…water efficiency is doing more with less – not doing without.” - CWCB

In agriculture, irrigation efficiency (IE)† is about maintaining CU-ET while lowering water delivery and application.

It is possible to have water leave the system (increased CU).

Return flows can be significantly diminished through foregone diversion - saved water remains in the system.

For a given acre of alfalfa, you would expect to maintain yields and hopefully improve yield.
Major advantages of efficiency include higher yields, lower labor costs, ability to change crop mixes, buffer drought and climate change, water quality improvement (Se) in the system, reduce fertilizer (N) losses.

Water becomes available to the next user who needs it.
CWCB-ATM Research (NoChicoBrush Group)

(Onions planted 4/5/2014)

15-Day Dryout  7-Day Dryout

Yield (lb/acre)

19%

Total Count

Furrow Irrigation  Drip Irrigation

Colossal  Jumbo  Medium  Pre-Pack
Other Irrigation Efficiency Research

![Graph showing irrigation efficiency]

- **2006**
- **15 bu/acre reduction**

**NoChicoBrush Irrigation Research Sites**
- (corn planted 4/25/2014)
- "5654 Dekalb"

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Yield (bu/acre)</th>
</tr>
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<tbody>
<tr>
<td>Dryland</td>
<td>213</td>
</tr>
<tr>
<td>50% ETc</td>
<td>228</td>
</tr>
<tr>
<td>75% ETc</td>
<td>228</td>
</tr>
<tr>
<td>100% ETc</td>
<td>228</td>
</tr>
<tr>
<td>125% ETc</td>
<td>228</td>
</tr>
</tbody>
</table>

**Legend**
- **Furrow Irrigation**
- **Pivot Irrigation**
Remote Sensing Innovations

We are starting to get a better handle on agricultural CU, without relying on assumptions.

Chávez and Cabot. Use of remote sensing tools to evaluate crop water stress and CU-ET
Are there technical challenges associated with irrigation efficiency?

Yes. Higher costs, learning curve, necessary system pressure, field configurations, water quality to name a few.
Conservation vs Efficiency both involve “forgone diversions” for transfers or “intentionally created surpluses.”

These terms are useful to discuss how water stays in the system.
Is it impossible to conserve water in agriculture without retiring land?

Yes ... because “conserving water” requires CU-ET reduction (e.g., land retirement, rotational fallowing, partial-season irrigation, System Conservation Program).

But it’s not the only solution being studied.
Just because a system is more efficient doesn’t mean that more water leaves the system.

This discussion makes sense if we’re talking about IE of one crop (predominantly alfalfa).

And up until now, we’ve been talking mainly about maximizing crop yield.
What about maximum economic yield?

Farming is about profitability through food production, not just some arbitrary goal of consuming water.

Irrigation water use efficiency (IWUE - crop per drop, profit-per-drop, etc) needs to be part of the conversation.
Crop Switching as an Efficiency Approach?

- Irrigation Water Use Efficiency (IWUE) – crop per drop
- Water Use Efficiency (WUE) – profit ($) per drop
- Genetically Modified Crops (drought tolerance)

### No Change

- Water Withdrawals: 100 UNITS
- Non-beneficial Losses: 20 UNITS
- Return Flows: 40 UNITS

### Conservation

- Water Withdrawals: 100 UNITS
- Non-beneficial Losses: 49 UNITS
- Return Flows: 68 UNITS

### Efficiency

- Water Withdrawals: 100 UNITS
- Non-beneficial Losses: 49 UNITS
- Return Flows: 53 UNITS

**Efficiency Details:**
- Water Withdrawals: 90% efficiency
- Return Flows: 58% efficiency
- Return Flows: 58% efficiency
Other Examples

Lower overall CU by reducing incidental non-consumptive losses, non-beneficial ET, evaporation in conveyance systems (Allen et al., 1996, Burt et al., 1997)
Other Examples

Lower overall CU through efficiency and field arrangement. Center-pivot sprinkler no irrigating corner-to-corner (Lamm et al, 2002).

“Quasi-retirement,” but there is still farming taking place and the farmer may be maximizing economic yield (IWUE)
Conversion to Center-Pivot Irrigation

Flood-Furrow Irrigation

Center-Pivot Sprinkler Irrigation
System example - Grand Valley Water Users Association

Structural and Operational Enhancements

• Additional canal checks
• New SCADA system for checks and spills
System example - Grand Valley Water Users Association

Unlined Canals

Lined Canals

Check Structures

Check Structures
GVWUA Efficiency and Innovations

For the years 2002-2014, the average annual forgone diversion was 46,682 AF.

Irrigation water deliveries were unaffected.

Kept water upstream in the system. Lower evaporation and incidental losses.

Harris, M. 2014. System Improvements and Foregone Diversions.
Conservation and Efficiency have different, but important benefits. There are many opportunities in Colorado to improve irrigation efficiency. We do not want to initiate a trend that we cannot reverse.
At least once in your life you’ll need a doctor, a lawyer, a policeman and a preacher, but three times a day, everyday, you need a farmer.
Conservation develops “conserved water”

Water previously released from the system (e.g., reservoir, river) as CU now stays

Return flows are partially diminished, and this water also remains.

Efficiency develops “saved water”

Change in CU depends on crop type – higher yields may release water from the system (e.g., reservoir, river).

If you are a farmer – this is a good thing. You are more resilient against drought and you might even be making more money.

Return flows are significantly diminished.