Virtual workshop series:
Water Resource Management and Irrigation in Kansas

Natural Resources PFT
Kansas Center for Agricultural Resources and the Environment (KCARE)
Theme 3: Water Resource Management and Irrigation in Kansas

- Offered as a Professional Development Event in PEARs for county extension agents

- 5 sessions in March and April, 8:30 am to 9:30 am
  - The next session is March 30, 2021

- Zoom Meeting ID: 952 6066 1935, passcode: water OR livestream on YouTube
Today’s format

• Please **mute** your microphones. Use the chat to sign in.
• Speakers will present for 30-40 minutes
• Panelists will join the discussion at the end
• Please ask questions through the **chat** function (located at the lower part of your screen).
• Although our “end time” is posted for 9:30 a.m., participants are welcome to remain longer if they want to discuss the topic further.
Water Resource Management and Irrigation in Kansas

Understanding irrigation systems and new technologies

Thursday, March 25, 2021
Speakers

Jonathan Aguilar
Associate Professor, Biological and Agricultural Engineering, Kansas State University

Bill Golden
Research Assistant Professor, Department of Agricultural Economics, Kansas State University

Matthew Sanderson
Randall C. Hill Distinguished Professor of Sociology, Anthropology, and Social Work, Kansas State University

Moderator

Aleksey Sheshukov, Associate Professor, Department of Biological and Agricultural Engineering, Kansas State University
Attitudes toward water in the High Plains-Ogallala Region

Matthew R. Sanderson, Ph.D.
Randall C. Hill Distinguished Professor of Sociology
& Professor of Geography and Geospatial Sciences
Kansas State University
Motivation?

• Time is running out
  – and it’s been a long time…

• Do not know much about:
  – how people view water
  – how/why they value it (or not)

• Where are shared values? Where are tensions?

• Then, can help build capacity… if this is a goal…

• Is there a problem?

• Whether people subject to this ‘problem’ actually believe there is a problem

• Conservation efforts lack legitimacy

• …if people that must face consequences of depletion do not believe there is a problem
Data and Methods

- January – July 2018
- 1,226 responses
- Represents target population [USDA Ag Census]
  - Age, Education, Income, Farm ops
- Good variation
  - 52% did not irrigate [n = 625]
  - 48% did irrigate [n = 578]
Should groundwater be saved or conserved?

- Yes or No
  - 94 no-response [7.7%]
- Overall ~ 9/10 say “yes”
  - 85% with non-responses
- By state, no fewer than 8/10 say “yes” [with non-responses]
  - CO = 81%
  - NE = 83%
  - TX = 84%
  - **KS = 90%**
  - OK = 92%
  - NM = 94%
Have views of the problem changed over 34 years?
How serious is the problem?

• Kromm and White:
  • Mean 3.74 [n = 956]: Serious to Very serious
  • 84%: Serious problem

• Our study: Same question
  1. In 14 K&W counties, mean is unchanged = 3.74 [n=294]: Serious
  2. 87%?: Serious problem
  3. Percentage viewing as a “Very Serious” problem declined ~20%
    – Note: K&W had more general public included
Does view of problem severity vary by state?

- Kromm and White did not seem to disaggregate

- **Clear difference between Nebraska and all other states [North to South]**
  - Nebraska = 42% [27% Serious + 15% Very Serious]
  - In 5/6 states: “super-majority” (2/3) “serious or very serious”
    - In TX and NM: *nearly ½ “very serious”*
  - Colorado = 67% [27% Serious + 40% Very Serious]
  - **Kansas = 74% [37% Serious + 37% Very Serious]**
  - Oklahoma = 80% [45% Serious + 35% Very Serious]
  - Texas = 83% [33% Serious + 50% Very Serious]
  - New Mexico = 85% [38% Serious + 47% Very Serious]
“Groundwater should be used. Groundwater does no good in the ground.”

• “Use ethic/value”
  – 1 = strongly disagree; 5 = strongly agree

• Only ~1/4 agree to some extent (24%)
• Of note:
  – ~ 1/3 are neutral [29%]
  – ~ 1/2 disagree to some extent [47%]

• Some difference across states…
“Groundwater should be used. Groundwater does no good in the ground.”

• Overall, 24% agree

• By state, no more than 1/3 agree or strongly agree:
  – CO = 33%
  – TX = 29%
  – NE = 27%
  – NM = 24%
  – OK = 19%
  – KS = 14%
“Groundwater levels are problem for my community”

- Overall, 47% agree

- Strong perception of community exposure **across the region**
  - Only in NE do <55% agree; in NE [only 29% agree]

- In all states, perception of **community problem is >** perception of personal problem
  - **In Kansas, the gap in perception (personal/community problem) is largest**

- TX: 80% [73% perceive it as a personal problem]
- NM: 76% [61%]
- CO: 67% [56%]
- **KS: 61% [37%] +24% difference**
- OK: 55% [47%]
- NE: 29% [23%]
Groundwater should be conserved today so that…

…it is available to producers if **commodity prices** are higher in the future.

39% Agree

…it is available to producers if **drought** becomes more frequent in the future.

73% Agree

Strongest agreement on altruistic measures…
Groundwater should be conserved today so that...

"...jobs and business opportunities continue to be available in my community in the future."

66% Agree

66% Agree

So, then what is groundwater “worth”?...
Summary & Implications

1. Nebraska is different

2. **Yes**, there is a legitimate problem, and it is perceived to be *about as severe as it was in 1984*
   - In near term (5 years), perceived stability in living standards

3. **Drought** is a major *personal* reason to conserve
   - Considerable perceived dependence with variation in *personal* exposure/vulnerability

• But…
Summary & Implications

5. A key aspect of the challenge is social/community-based
   - Pushing tech adoption further can still play role; many doing what they can
   - Will be more about extending technologies, broadening uptake
   - May be more limited, but could be means of building networks, capacities, culture of conservation...

6. Despite variation in personal exposure/vulnerability, perception of community dependence is stronger and less variable
   - Likely even higher among public

7. Good news: seems to be sufficient altruism
   - Strong majorities see a future for others in the region as most important reason to conserve
   - E.g., jobs, businesses, future generations, my kids and grandkids
Funding Agencies and Partners

United States Department of Agriculture
National Institute of Food and Agriculture

OgallalaWater.org

Kansas State University
IRRIGATION TRENDS AND MANAGEMENT TOOLS

Jonathan Aguilar, PhD, PE

Assoc. Professor/ Water Resource Engineer
K-State Southwest Research –Extension Center
Garden City, KS
KEY ITEMS

- Irrigators are doing something, but...
- Irrigation water is important, but...
- How to navigate through the tools/tech
Why Irrigate?

• Improve Yield
  • Narrow Yield Gap
  • Increase Net Return

• Stabilize Yield

• Improve Product Quality

• Improve Local Economy

• Reduce Risks (rainfall timing)
Kansas Precipitation

Figure 3. Normal annual precipitation (1961 - 1990) in Kansas. The area west of the dashed line shows the extent of the High Plains aquifer in Kansas (from Goodin et al., 1995).
## Improve Yield

<table>
<thead>
<tr>
<th>Time of Irrigation</th>
<th>1991 Yield Bu/Ac</th>
<th>1980-1991 Bu/Ac</th>
<th>1991 Irrigation Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Irrigation</td>
<td><strong>3</strong></td>
<td><strong>56</strong></td>
<td>None</td>
</tr>
<tr>
<td>1X (Tassel)</td>
<td><strong>124</strong></td>
<td><strong>141</strong></td>
<td>7/8</td>
</tr>
<tr>
<td>2X (Tassel + 1 week)</td>
<td>148</td>
<td>159</td>
<td>7/8, 7/15</td>
</tr>
<tr>
<td>3X (Tassel + 1 wk + 2 wks)</td>
<td>155</td>
<td>164</td>
<td>7/8, 7/15, 7/25</td>
</tr>
<tr>
<td>2X (65% depletion)</td>
<td>159</td>
<td>172</td>
<td>7/1, 7/23</td>
</tr>
</tbody>
</table>
Stabilize yield

Kansas Corn Yield Trend

Irrigated yield trend: \( y = 2.0762x + 112.29 \)

Dryland yield trend: \( y = 0.7489x + 63.542 \)
Total irrigated area by system in Kansas
Kansas: 1989 – 2017 Irrigated Acres

<table>
<thead>
<tr>
<th>Reporting Unit</th>
<th>1989</th>
<th>2012</th>
<th>2017</th>
<th>Change</th>
<th>% Change since 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
<td>in acres</td>
<td></td>
</tr>
<tr>
<td>GMD 1</td>
<td>291,574</td>
<td>198,377</td>
<td>177,528</td>
<td>-114,046</td>
<td>-39.1</td>
</tr>
<tr>
<td>GMD 3</td>
<td>1,572,470</td>
<td>1,424,923</td>
<td>1,393,101</td>
<td>-179,369</td>
<td>-11.4</td>
</tr>
<tr>
<td>GMD 4</td>
<td>359,016</td>
<td>387,286</td>
<td>392,003</td>
<td>32,987</td>
<td>9.2</td>
</tr>
<tr>
<td>Rest of Region 1 (West)</td>
<td>106,915</td>
<td>109,220</td>
<td>113,022</td>
<td>6,107</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>Total of Region 1 (West)</strong></td>
<td><strong>2,329,975</strong></td>
<td><strong>2,119,806</strong></td>
<td><strong>2,075,654</strong></td>
<td><strong>-254,321</strong></td>
<td><strong>-10.9</strong></td>
</tr>
<tr>
<td>GMD 2</td>
<td>94,683</td>
<td>136,543</td>
<td>150,786</td>
<td>56,103</td>
<td>59.3</td>
</tr>
<tr>
<td>GMD 5</td>
<td>429,133</td>
<td>456,746</td>
<td>458,119</td>
<td>28,986</td>
<td>6.8</td>
</tr>
<tr>
<td>Rest of Region 2 (Central)</td>
<td>192,664</td>
<td>248,916</td>
<td>273,152</td>
<td>80,488</td>
<td>41.8</td>
</tr>
<tr>
<td><strong>Total of Region 2 (Central)</strong></td>
<td><strong>716,480</strong></td>
<td><strong>842,205</strong></td>
<td><strong>882,057</strong></td>
<td><strong>165,577</strong></td>
<td><strong>23.1</strong></td>
</tr>
<tr>
<td><strong>Total of Region 3 (East)</strong></td>
<td><strong>52,375</strong></td>
<td><strong>80,070</strong></td>
<td><strong>100,809</strong></td>
<td><strong>48,434</strong></td>
<td><strong>92.5</strong></td>
</tr>
<tr>
<td><strong>State</strong></td>
<td><strong>3,098,830</strong></td>
<td><strong>3,042,081</strong></td>
<td><strong>3,058,520</strong></td>
<td><strong>-40,310</strong></td>
<td><strong>-1.3</strong></td>
</tr>
</tbody>
</table>
Reduce Risks during critical stages
IRRIGATION MANAGEMENT IS KEY

- System Efficiency
- Application Efficiency
- Planning Tools
- Scheduling
- Strategies
A pair of binoculars IS NOT an irrigation technology

SURVEY SAYS:
MY IRRIGATION SCHEDULE DEPENDS ON MY NEIGHBOR
Kansas Farms (%) Using Irrigation Schedule

- **Soil Sensing**
  - 2008: 12%
  - 2013: 11%
  - 2018: 19%

- **Plant Sensing**
  - 2008: 3%
  - 2013: 2%
  - 2018: 2%

- **ET-based**
  - 2008: 17%
  - 2013: 17%
  - 2018: 17%

- **Neighbors**
  - 2008: 3%
  - 2013: 1%
  - 2018: 3%
US Farms (%) Using Irrigation Schedule

- Soil Sensing
- Plant Sensing
- ET-based
- Neighbors

<table>
<thead>
<tr>
<th>Year</th>
<th>Soil Sensing</th>
<th>Plant Sensing</th>
<th>ET-based</th>
<th>Neighbors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>7</td>
<td>1</td>
<td></td>
<td>7</td>
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<tr>
<td>2008</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>2013</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>2018</td>
<td>12</td>
<td>2</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>
How to Schedule

Weather-based

Soil-based

Plant-based
Irrigation Scheduling Tools

- Weather-based
  - KanSched
  - ET Gauge/Atmometer
  - Checkbook method
  - DIEM - TX
  - WISE - CO
  - K-State Mesonet
  - FRET - NOAA
Irrigation Scheduling Tools

- Gravimetric
- Tensiometer
- Soil Water Potential
- Neutron count
- Electrical Resistance
- Electromagnetic
- Hand probe / feel

Soil-based
Irrigation Scheduling Tools

- Infrared / Thermal Camera
- Dendrometer
- Micro-tensiometer
- Osmotic/water potential
- NDVI/Aerial Imagery
- Visual

Plant-based
Use One or More Feedback for Scheduling

Weather-based

Soil-based

Plant-based

The Low Hanging Fruit
In water management/conservation

NOT ONE TOOL IS PERFECT, BUILDS CONFIDENCE
Please update your links and watch out for its upgrade
KanSched 3 – online version (beta)
KanSched 4 – mobile app (beta – test users)

Your Fields

Your fields are displayed below. Use Field Collections to further organize your fields by dragging and dropping them into appropriate groups. To add a new Field Collection, simply enter a name in the text box to the right, then press the button.

+ Add a new field  + Add Demo Field

Individual Field Collection

<table>
<thead>
<tr>
<th>Field Collection</th>
<th>Type</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILS Farm 2018</td>
<td>Corn</td>
<td>Setup, Budget, Chart, Notes, Summary, Delete</td>
</tr>
<tr>
<td>Colby, KS Demo Field 2012</td>
<td>Corn</td>
<td>Setup, Budget, Chart, Notes, Summary, Delete</td>
</tr>
<tr>
<td>Meade 1</td>
<td>Corn</td>
<td>Setup, Budget, Chart, Notes, Summary, Delete</td>
</tr>
</tbody>
</table>
TIPS on selecting soil water sensor

- Soil Type, Location, location, location
- Costs include subscription
- After-sales support is vital
- Easy integration to your operation

Soil Moisture Monitoring

- How can soil moisture monitoring help conserve groundwater?
- Knowing when to water and how much water to apply is an important first step in conserving groundwater. Monitoring soil moisture provides information useful for determining crop water needs and scheduling irrigation.

What are the available options in soil moisture monitoring?

- One way soil moisture can be determined is by weighing a soil sample when it is collected from the field, weighing again after the sample is dried, and then calculating the difference in weight to determine the moisture level. This direct measurement method, called the gravimetric method, is accurate, but it is also destructive to the soil, time-consuming, and costly.

Consequently, other indirect methods and technologies (Figure 1) have been developed to estimate soil water levels. These technologies vary in their methods for estimating soil moisture, and as a result, can range in their performance and can be impacted by different factors. (Rudnick et al., 2017).

Soil water sensing is just one of three feedbacks to schedule irrigation. Using more of these independent methods gives you greater confidence.

Selection and implementation of your sensors.

- Make sure the irrigation system is at optimum operating condition.
- Verify the irrigation capacity and plan an appropriate management strategy.
- Be willing and ready to turn off the system when the feedback says so.
- Make a conscious effort to check feedbacks daily.
- When in doubt, check the field.
- Be prepared to question your crop advisor when your feedback says otherwise.

Soil water sensor costs are associated with three components: equipment, installation, and maintenance/service or subscription. It is important to install the sensor in the correct location to maximize the soil, plant population, and topography monitoring at least two days. Also consider equipment sites, timing, and subsequent field operations in choosing the location.
Soil Moisture Sensor Demonstration Videos

Type: bit.ly/SensorDemo

Recognized: 2018 ASABE Blue Ribbon Award
MORE RESOURCES

- milab.ksu.edu
- ksre.k-state.edu/irrigate
- www.ogallalawater.org
- irrigationtoday.org
- Opportunity: IA’s Agriculture Faculty Academy
THANK YOU

Contact info:
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620-640-1342 (Mobile)
Follow: @ksirrigation
Economics of Producer-Driven Groundwater Pumping Reductions in Kansas

Dr. Bill Golden

Water resource management and irrigation in Kansas
Understanding Irrigation Systems and New Technologies
March 25, 2021

This research was funded in part by the Kansas Water Office under Contract # 15-0112, the USDA Ogallala Aquifer Project, and the U.S.D.A. – N.I.F.A. Ogallala Water CAP Project
LEMA’s are initiated by local producers – but after enactment carry the weight of law
LEMA’s set their own rules
LEMA’s are reversible
Sheridan #6: 5 year 55” allocation => about a 20% reduction
Big Question

• What happens to producer income as we reduce groundwater usage?

• Past evidence is not consistent !!!
Example from Southwest Kansas. Both curves exhibit diminishing marginal returns to applied groundwater. Curves vary by crop, location, precipitation, and time.
What We Have Observed: Wet Walnut Creek IGUCA: Irrigated Crop Revenue

Figure 6. Time Series Comparison of the Indexed Values of Irrigated Crop Revenue

Statistically significant short-run and a statistically insignificant long-run reduction in annual irrigated crop revenue.
Since the Evidence is Not Consistent

• We need to monitor irrigated acreage and water use in Sheridan #6 LEMA in real time. Will producers:
  • Shift acres to dryland production
  • Maintain crop mix and reduce water use per acre
  • Shift to crops that require less water

• What are the economic consequences of these changes
Research Question

• How did the production decisions the producers inside the LEMA made, compare to the production decisions the producers outside the LEMA made

• This originally was a 5-year study.
Sheridan #6 LEMA

Control Area

Target Area
Why Do We Compare Decisions?
Why Do We Compare Decisions?
Results

Total Water Use (all crops)

Approximately 23.1% reduction; statistically significant

Based on KDA water use reports
Results

Average Water Use per Acre (all crops)

Approximately 16.0% reduction; statistically significant
Based on KDA water use reports
Results

Total Irrigated Corn Acreage

Approximately 23.3% reduction; statistically significant

Based on KDA water use reports
Results

Irrigated Corn Acreage Water Use

Approximately 17.8% reduction; statistically significant

Based on KDA water use reports
Results

Total Irrigated Sorghum Acreage

Approximately 335.4% increase; statistically significant

Based on KDA water use reports
# 2013-2017 Producer Reported Economic Data

<table>
<thead>
<tr>
<th>Item</th>
<th>Observations</th>
<th>Water Use (in/ac)</th>
<th>Yield (bu/ac)</th>
<th>Cash Flow ($/ac)</th>
<th>Cash Flow ($/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Weighted Average - Inside LEMA</td>
<td>20</td>
<td>10.3</td>
<td>218.0</td>
<td>$375</td>
<td>$36</td>
</tr>
<tr>
<td>Corn Weighted Average - Outside LEMA</td>
<td>11</td>
<td>13.4</td>
<td>220.6</td>
<td>$360</td>
<td>$27</td>
</tr>
<tr>
<td>Sorghum Weighted Average - Inside LEMA</td>
<td>4</td>
<td>4.3</td>
<td>152.6</td>
<td>$361</td>
<td>$83</td>
</tr>
<tr>
<td>Sorghum Weighted Average - Outside LEMA</td>
<td>1</td>
<td>11.0</td>
<td>177.0</td>
<td>$226</td>
<td>$21</td>
</tr>
<tr>
<td>Soybeans Weighted Average - Inside LEMA</td>
<td>5</td>
<td>9.5</td>
<td>59.6</td>
<td>$315</td>
<td>$33</td>
</tr>
<tr>
<td>Soybeans Weighted Average - Outside LEMA</td>
<td>4</td>
<td>9.7</td>
<td>70.0</td>
<td>$358</td>
<td>$37</td>
</tr>
<tr>
<td>Sunflowers Weighted Average - Inside LEMA</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Sunflowers Weighted Average - Outside LEMA</td>
<td>1</td>
<td>6.0</td>
<td>2818</td>
<td>$788</td>
<td>$131</td>
</tr>
<tr>
<td>Wheat Weighted Average - Inside LEMA</td>
<td>5</td>
<td>5.7</td>
<td>76.3</td>
<td>$219</td>
<td>$38</td>
</tr>
<tr>
<td>Wheat Weighted Average - Outside LEMA</td>
<td>3</td>
<td>7.4</td>
<td>81.8</td>
<td>$178</td>
<td>$24</td>
</tr>
</tbody>
</table>
Current LEMA Status

- District Wide LEMA in GMD #4
- Sheridan #6 LEMA extended for another 5 years, with larger reductions than required by the district wide LEMA.
- KGS indicates that groundwater declines are being reduced
- Producers report enhanced profits due to
  - Irrigation scheduling with soil moisture probes
  - Better management
Future Research

• Are we really 95% efficient with our current groundwater use
• Estimate season-long WUE
Questions
Water resource management and irrigation in Kansas

**Upcoming session:** Tuesday, March 30, 8:30am

**Topic:** Climate and weather resources to support water decisions

**Presenters:** Mary Knapp, Climatologist, Kansas State University; and Christopher “Chip” Redmond, Assistant Agronomist, Kansas State University

**Hosted by:** Natural Resources PFT and KCARE