Impacts of Climate Change on Water Management in Agriculture

Projected Change in Annual Total Precipitation by Mid-Century
Period: 2040-2059 | Higher Emissions: RCP 8.5

GLISA
A NOAA RISA TEAM
Data Source: Univ. of Wisc. Nelson Institute Center for Climatic Research

Change in Annual Total Precipitation (in./year)
-1.0 -0.5 0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 Miles
0 40 60 160 240

Michigan State University Extension
Impacts of Climate Change on Water Management in Agriculture
Impacts of Climate Change on Water Management in Agriculture

Longest period without precipitation during the growing season (May - September).
Most seasons require irrigation to prevent yield loss.
Natural Resources Conservation Service (NRCS) classified soils based on texture and water table depth into Hydrologic Soil Groups.

**Example Texture of Each Soil Group**
A: Sands or gravel  
B: Sandy loam, loam, silt loam, and silt  
C: Clay loam  
D: Clay

**Group A/D, B/D, C/D**
Soils classified as A/D, B/D and C/D have a high water table, which means low ability to move the water out of the root zone. If it is drained, it is considered as the first letter.
Hydrological Soil Map - Indiana

Natural Resources Conservation Service (NRCS) classified soils based on texture and water table depth into Hydrologic Soil Groups.

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Soils classified as A/D, B/D and C/D have a high water table, which means low ability to move the water out of the root zone. If it is drained, it is considered as the first letter.
Registration request (using data Available November 2021)
Irrigation Scheduling

Weather-based Irrigation Scheduling

Sensor-based Irrigation Scheduling
Water Holding Capacity - Soil Sampling

The simple yet powerful way to access and use soil data.

Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation’s counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Soil surveys can be used for general farm, local, and wider area planning. Onsite investigation is needed in some cases, such as soil quality assessments and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center at the following link: USDA Service Center or your NRCS State Soil Scientist at the following link: NRCS State Soil Scientist.
Water Holding Capacity - USDA Web Soil Survey

5B Spinks, Loamy Sand Soil

4B Oshtemo, Sandy Loam Soil
Current Irrigation Management Practices

Weather-based Irrigation Scheduling

\[ ET_C = K_C \times rPET \]

Where,

\( ET_C \) = Actual Crop Evapotranspiration (in/day)

\( K_C \) = Crop Coefficient (unitless multiplier)

\( rPET \) = Reference Potential Evapotranspiration (in/day)

Sensor-based Irrigation Scheduling
Weather-based Irrigation Scheduling - Crop Evapotranspiration

\[ ET_C = rPET \times K_C \]

Where,

- \( ET_C \) = Actual Crop Evapotranspiration (in/day)
- \( rPET \) = Reference Potential Evapotranspiration (in/day)
- \( K_C \) = Crop Coefficient (unitless multiplier)

---

**Corn Kc (Pokorny, 2019)**

**Soybean Kc**
Reference Potential Evapotranspiration

https://www.weather.gov/ict/Evapotranspiration
Reference Potential Evapotranspiration
Where,

\[ ET_C = K_C \times rPET \]

\[ ET_C = 1.1 \times 0.83 \text{ in} = 0.91 \text{ in} \]
MSU Irrigation Scheduler Program

www.egr.msu.edu/bae/water/irrigation
MSU Irrigation Scheduler Program

MSU Excel Irrigation Schedule Checkbook Method - Mendon 2014

Plant Available Water

- Full water holding line
- Allowable depletion line (60% of available water)
- Allowable depletion line (40% of available water)
- Wilt & potential yield reduction
- Leaching

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainfall</th>
<th>Irrigation</th>
<th>Crop Et</th>
<th>Forecasted Et</th>
<th>Drainage</th>
<th>AW Above</th>
<th>Additional</th>
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</thead>
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<tr>
<td>7/5/2021</td>
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<td>0.16</td>
<td>0.16</td>
<td>0.06</td>
<td>0.00</td>
<td>0.06</td>
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<td>0.00</td>
<td>0.06</td>
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<tr>
<td>7/7/2021</td>
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<td>0.06</td>
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<td>7/8/2021</td>
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<td>7/9/2021</td>
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<td>0.16</td>
<td>0.06</td>
<td>0.00</td>
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<tr>
<td>7/10/2021</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
<td>0.06</td>
<td>0.00</td>
<td>0.06</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Totsal: 1.68 0 1.14 0.52 1.33

Please note: projected values do not include forecasted rainfall, only the outlook Et values. Irrigation Threshold: Dropping below this level may cause yield loss. To avoid, initiate irrigation. Environment Station Selected: Constance
Updating MSU Irrigation Scheduler – (In-progress)
MSU Irrigation Scheduling Mobile App (In-progress)

If you are interested in trying Beta version, please leave a note it in the survey.
Current Irrigation Management Practices

Weather-based Irrigation Scheduling

Sensor-based Irrigation Scheduling

\[ ET_C = K_C \times rPET \]

Where,

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- \( rPET \) = Reference Potential Evapotranspiration (in/day)
Soil Moisture Sensor-based Irrigation Scheduling Method
Soil Tension – WATERMARK Sensor

Measures the actual soil water tension, which indicates the effort required by root system to extract water from the soil.

Soil Matric Potential for 30%, 50%, and 70% of soil water depletion for different soil types (Irmak et al., 2014)
Frequency Domain Reflectometry – Volumetric Water Content

Frequency Domain Reflectometry (FDR) sensors measure soil water content using the dielectric properties of soil which are highly dependent on moisture content.

Recommended irrigation trigger point for different soil types

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Trigger Point Range (Irrigate when VWC falls below these values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>7 - 8 %</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>8 - 10 %</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>12 - 15 %</td>
</tr>
<tr>
<td>Loam</td>
<td>20 - 26 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Dielectric permittivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1</td>
</tr>
<tr>
<td>Soil Minerals</td>
<td>3~7</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>2~5</td>
</tr>
<tr>
<td>Ice</td>
<td>5</td>
</tr>
<tr>
<td>Water</td>
<td>80</td>
</tr>
</tbody>
</table>
Center Pivot Irrigation - 2023
Drip Irrigation - 2023
Crop type: Commercial Corn
Stage (7/4/23): V5
Soil: Oshtemo Sandy Loam Soil
Recommended Irrigation Management - Corn

Most critical time for Corn plants to have adequate water is from VT until R6.
Recommended Irrigation Management - Soybean

- Most critical times for Soybean plants to have adequate water are during pod development (R3 - R4) and seed fill (R5 - R6).
- Not enough moisture during the critical stages (R3-R6) in sandy soil field can reduce yield up to 28 bu/acre.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Average numbers of days</th>
<th>Range in number of days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning to VE</td>
<td>10</td>
<td>5 to 15</td>
</tr>
<tr>
<td>VE to VC</td>
<td>5</td>
<td>3 to 10</td>
</tr>
<tr>
<td>VC to V1</td>
<td>5</td>
<td>3 to 10</td>
</tr>
<tr>
<td>V1 to V2</td>
<td>5</td>
<td>3 to 10</td>
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<tr>
<td>V2 to V3</td>
<td>5</td>
<td>3 to 10</td>
</tr>
<tr>
<td>V3 to V4</td>
<td>5</td>
<td>3 to 8</td>
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<tr>
<td>V4 to V5</td>
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<tr>
<td>Beyond V5</td>
<td>3</td>
<td>2 to 5</td>
</tr>
<tr>
<td>R1 to R2</td>
<td>3</td>
<td>0 to 7</td>
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<tr>
<td>R2 to R3</td>
<td>10</td>
<td>5 to 15</td>
</tr>
<tr>
<td>R3 to R4</td>
<td>9</td>
<td>5 to 15</td>
</tr>
<tr>
<td>R4 to R5</td>
<td>9</td>
<td>4 to 26</td>
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<tr>
<td>R5 to R6</td>
<td>15</td>
<td>11 to 20</td>
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<tr>
<td>R6 to R7</td>
<td>18</td>
<td>9 to 30</td>
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<tr>
<td>R7 to R8</td>
<td>9</td>
<td>7 to 18</td>
</tr>
</tbody>
</table>

Source: University of Minnesota

Source: Shaun Casteel, Purdue University.
Sensor Installation Considerations

- Root depth.
- Representative area.
  - Soil type
  - Slope
  - Crop type
- Installation technique
  (No air gap)
Sensor Installation Considerations

• Root depth.
• Representative area.
  o Soil type
  o Slope
  o Crop type
• Installation technique
  (No air gap)
## Corn Irrigation On-Farm Demonstration Project Updates

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Yield (bu/acre)</th>
<th>Irrigation Water Use Efficiency (bu/acre-inch)</th>
<th>Value ($/acre-inch)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer’s Irrigation Management</td>
<td>305</td>
<td>19.5</td>
<td>132</td>
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<tr>
<td>100% Irrigation Scheduling</td>
<td>319</td>
<td>22.4</td>
<td>152</td>
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<tr>
<td>130% Irrigation Scheduling</td>
<td>319</td>
<td>19.3</td>
<td>131</td>
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<tr>
<td>70% Irrigation Scheduling</td>
<td>309</td>
<td>20.3</td>
<td>137</td>
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<tr>
<td>Dry Corner</td>
<td>218</td>
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</tbody>
</table>

*Assumed that corn price is $6.77/Bushel (1/20/23)
## Soybean Irrigation On-Farm Demonstration Project Updates

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Yield (bu/acre)</th>
<th>Irrigation Water Use Efficiency (bu/acre-inch)</th>
<th>Value ($/acre-inch)</th>
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</thead>
<tbody>
<tr>
<td>Producer’s Irrigation Management</td>
<td>64</td>
<td>6.3</td>
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<tr>
<td>100% Irrigation Scheduling</td>
<td>66</td>
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<td>122</td>
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<tr>
<td>130% Irrigation Scheduling</td>
<td>66</td>
<td>6</td>
<td>92</td>
</tr>
<tr>
<td>70% Irrigation Scheduling</td>
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<td>4.5</td>
<td>69</td>
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<tr>
<td>Dry Corner</td>
<td>54</td>
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</tbody>
</table>

**Assumed that soybean price is $15.3/Bushel (1/19/23)**
Irrigation System Uniformity Evaluation

The precision of the uniformity testing decreases when wind exceed 2.2 mph.

If wind speed goes beyond 11 mph, the test may not be a valid.
Importance of Checking Irrigation System Uniformity

• Poor water distribution can result in over- and under-irrigated areas.
• Under-irrigation can reduce crop yield and grain quality.
• Over-irrigation can cause runoff and leaching water and nutrients below the root zone.
• Low uniformity can negatively impact on a farm’s net return and environmental impacts.

(MJC Irrigation Technology, n.d.)
Irrigation System Uniformity Evaluation

<table>
<thead>
<tr>
<th>MSU Extension Irrigation System Evaluation Tool, 1-23-07</th>
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<tbody>
<tr>
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<td>34</td>
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</tbody>
</table>

If the CU is 85% or greater, the irrigation system is not likely to need major adjustments to the sprinkler package,

A CU of 80 to 85% may need further analysis of the sprinkler package, and individual sections of the irrigator would benefit from corrections.

A CU of less than 80% requires an adjustment to the sprinkler package design and correction of individual sections of the sprinkler package.
Irrigation System Evaluation – Case study

• Material and labor costs for replacing sprinkler package were $4,360 and $2,220, respectively. Total cost was $6,580.
• With $1,617 in energy savings per year, the payback period of updating the sprinkler system is approximately 4 years.
Looking for Collaborators!!

Younsuk Dong  lyndon kelley

dongyoun@msu.edu  kelleyl@msu.edu

(517) 432-8751  (269) 467-5511

Support $1,000 for the cost of the retrofit.
USDA NRCS EQIP (Environmental Quality Incentives Program)

United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, MICROIRRIGATION

CODE 441
(Ac.)

DEFINITION
An irrigation system for frequent application of small quantities of water on or below the soil surface: as drops, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line.

PURPOSE
This practice is applied to achieve the following purpose:
- Efficiently and uniformly apply irrigation water and maintain soil moisture for plant growth.
- Prevent contamination of ground and surface water by efficiently and uniformly applying chemicals.
- Establish desired vegetation (e.g., windbreaks).

CONDITIONS WHERE PRACTICE APPLIES
This practice applies on sites where soils and topography are suitable for irrigation of crops or other desirable vegetation and an adequate supply of suitable quality water is available for the intended purpose(s).

Microirrigation is suited to virtually all agricultural crops, and residential and commercial landscape systems. Microirrigation is also suited to steep slopes where other methods would cause excessive erosion, and areas where other application devices interfere with cultural operations.

Microirrigation is suited for use in providing irrigation water in limited amounts to establish desired vegetation such as windbreaks, living snow fences, riparian forest buffers, and wildlife plantings.

This practice standard applies to systems that wet only a specific area (e.g., an individual plant or tree) and typically have design discharge rates less than 60 gal/hr at individual application discharge points.

Use NRCS Conservation Practice Standard (CPS) Code 442, Sprinkler System, for systems that uniformly wet the entire field and typically have design discharge rates of 60 gal/hr or greater at individual application discharge points.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SPRINKLER SYSTEM

Code 442
(Ac.)

DEFINITION
A distribution system that applies water by means of nozzles operated under pressure.

PURPOSE
This practice is applied as part of a conservation management system to accomplish one or more of the following:
- Efficient and uniform application of water on irrigated lands
- Improve plant condition, productivity, health and vigor
- Prevent the entry of excessive nutrients, organisms, and other chemicals in surface and groundwater
- Improve condition of soil contaminated with salts and other chemicals
- Reduce particulate matter emissions to improve air quality
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES
This standard applies to the planning and functional design of all sprinkler system components (e.g., laterals, risers, nozzles, heads, and pressure regulators).

Individual sprinkler design discharge rates covered by this standard typically have design nozzle discharge rates exceeding 1 gallon per minute and wet the entire field surface uniformly.

Areas must be suitable for sprinkler water application, and have a water supply of adequate quantity and quality for intended purpose(s).

This standard applies to planning and design of sprinkler application systems for:
- Meeting crop water demands
- Crop cooling, frost protection, or bloom delay
- Leaching or leaching of saline or sodic soils, or soils contaminated by other chemicals that can be controlled by leaching
- Application of chemicals, nutrients, and/or waste water

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER MANAGEMENT

CODE 449
(Ac.)

DEFINITION
The process of determining and controlling the volume, frequency, and application rate of irrigation water.

PURPOSE
This practice is used to accomplish one or more of the following purposes:
- Improve irrigation water use efficiency
- Minimize irrigation-induced soil erosion
- Protect surface and ground water quality
- Manage salts in the crop root zone
- Manage soil, soil, or plant microclimate
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES
This practice is applicable to all currently irrigated lands.

CRITERIA
General Criteria Applicable to All Purposes
Develop an irrigation water management (IWM) plan that defines when irrigation is needed (timing) and the amount and rate of water to apply for each irrigation event.

Base the timing of irrigation on one or more of the following methods:
- Evapotranspiration of the crop, using appropriate crop coefficients and reference evapotranspiration data.
- Soil moisture monitoring.
- Computed irrigation scheduling, utilizing local real-time climate data, soil, and crop growth characteristics (e.g., remote sensor data systems coupled with dilution-based irrigation scheduling using the soil-water balance method).
- Plant monitoring (e.g., leaf water potential or leaf canopy temperature measurements).
Resources

MSU Extension – Irrigation
https://www.canr.msu.edu/irrigation
https://engineering.purdue.edu/ABE/extension/H2OQual/Irrigation

RISK OF IRRIGATION WATER ON THE ROAD
PUBLISHED ON AUGUST 25, 2023
The risk associated with irrigation water on the road depends on the pressure and volume of water hitting the road and amount of traffic encountering it.

THE IMPORTANCE OF CHECKING IRRIGATION SYSTEM UNIFORMITY
PUBLISHED ON AUGUST 18, 2023
Evaluating and retrofitting your irrigation system can help to improve irrigation water use efficiency.

ADEQUATE WATER SUPPLY IS THE HEART OF AN IRRIGATION SYSTEM
PUBLISHED ON AUGUST 16, 2023
Irrigation investments start with securing an adequate water supply that meets the state legal requirements for large-scale water use and minimal potential for conflict with neighbors or adverse resource impacts.

MSU EXTENSION HOSTS SECOND ANNUAL BLUEBERRY RESEARCH FIELD DAY
PUBLISHED ON JULY 18, 2023
Join Michigan State University Extension for this blueberry-focused event on Sept. 6 in Fennville.

JUNE CROP WATER NEEDS
PUBLISHED ON JUNE 18, 2023
If soils are depleted of moisture beneath the developing plants, irrigators need to supply enough water to help establishing roots grow down into natural soil moisture.
Future Irrigation-Related Events

- Irrigation Scheduling
- Value of Irrigation Uniformity and Sprinkler Choice
- Irrigation Electrical Safety
- Pivot Control System

Feb 27. 2024
Zoom
MSU WATER USE EFFICIENCY EXTENSION EDUCATOR

POSITION SUMMARY

MSU Extension is searching for educators to fill two Water Use Efficiency positions. One position will be located in West Michigan in Mason County. The other position will be located in Southern Michigan in Branch County.
Younsuk Dong
dongyoun@msu.edu

Lyndon Kelley
kellyl@msu.edu

MSU Extension – Irrigation
https://www.canr.msu.edu/irrigation